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THE TECH ENGINEERING NEWS

NOVEMBER 1921

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Monthly News

VOL. II NO. 5

The WORLD'S WORD for ELEVATOR SAFETY

The WORLD'S WORD for ELEVATOR SAFETY

THE CAPITOL BUILDING

BUENOS AIRES, ARGENTINA

Most of the famous buildings of the world are equipped with Otis Elevators.

IF architecture be "frozen music" this is indeed a symphony in stone! Certainly it is one of the most beautiful buildings in South America. And quite naturally it is equipped with Otis Elevators.

The aim of the Otis organization is a world service in vertical transportation. No country is "foreign" in this respect. If there be any demand from any race in any country to build upward—one of the sure signs of advancing civilization—the Otis institution is ready to fill that demand.

It is a unique position for one firm to hold in any industry; to have been the first in the field, to have made practically all the improvements in the conception and mechanism of vertical transportation and to maintain a leadership that has never been seriously challenged even in this day of industrial competition.

OTIS ELEVATOR COMPANY

Offices in all Principal Cities of the World

Hercules Dynamite for Good Roads

Hercules Dynamite is helping thousands of highway engineers and contractors to solve the great variety of problems that face them.

With the help of Hercules Powders these men are grading roadbeds—driving cuts and tunnels through hard rock—ditching swamps and clearing right of ways in every part of the United States. In fact, Hercules Explosives are a very important factor in the present drive for good roads.

The high and uniform quality of these powders —their reliability and great efficiency under all blasting conditions — make them particularly adaptable for road work.

If we can help you with your blasting problems write us. Our service staff will answer your questions promptly and fully.

HERCULES POWDER CO.

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New York City
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Pittsburgh. Pa.
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St. Louis, Mo.
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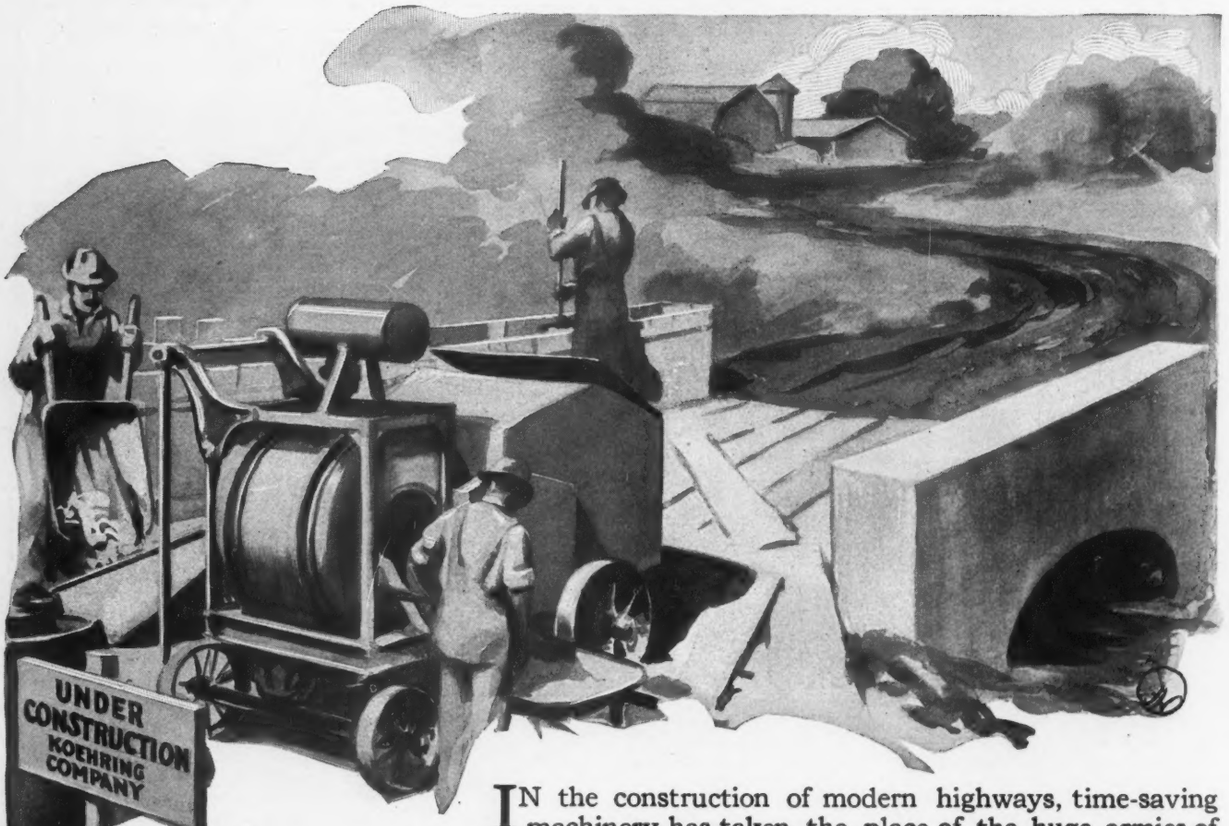
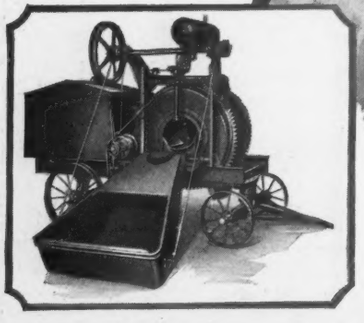
Wilmington, Del.



IN the construction of modern highways, time-saving machinery has taken the place of the huge armies of artisans which, by brute strength accomplished the road-building of the Egyptians and Romans.

The nerve center from which modern highway building radiates is the concrete mixer. Without it, the present wonderfully developed system of paved roads would be only a chimerical dream.

The concrete mixer has made possible the economical building of culverts, the rapid construction of bridges and approaches, the placing of concrete foundation for brick and other two-course pavements, and—probably its greatest achievement of all—the construction of the thousands of miles of smooth, hard and enduring concrete roads reaching across all sections of the land.



There is a particular type of concrete mixer for each of these phases of road engineering.

Culvert construction demands very much different equipment from paving construction. An average culvert requires the mixing of only a few cubic yards of concrete. Wherever, along the road to be paved, a cross ditch or sharp hollow happens to lie, there a culvert must be built.

To meet these conditions the Koehring Dandy Light Mixer is used. It is sturdy and substantial, yet light in weight and easily portable from culvert to culvert in quick time by truck or team.

The Dandie's quick mobility arises in part from its small size; its capacity of 4 and 7 cubic feet of mixed concrete are just right for the well planned culvert project.

KOEHRING COMPANY

Manufacturers of Concrete Mixers and Locomotive Cranes

MILWAUKEE, WISCONSIN

KOEHRING

The Tech Engineering News

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STAINED AND PAINTED GLASS

By CHARLES J. CONNICK

Windows in colored leaded glass have long been known, popularly and technically as "stained glass windows," but the term is not comprehensive, as all colors, with the exception of a true yellow stain obtained by silver salts, are colored in the pot when the glass is made, or white glasses are flashed with thin coatings of colored glass. Most reds are obtained by the latter method.

Both colored and white glasses are painted and leaded, and the distinctive features of stained glass windows are, in fact, more accurately described by the terms "painted and leaded."

THIRTEENTH CENTURY STAINED GLASS
Window in the Cathedral at Poitiers, France

This noble craft has inspired lovers of glowing color since primitive colored glass was made, and the happy expedient of enlisting daylight to vitalize an artist's expression was first employed.

To those who respond to its distinctive appeal, all other mediums seem at times tame and ineffectual by comparison. It alone, among the materials with which we are familiar, offers the singing splendor of pure transparent color transfused with light.

Its very limitations, in the hands of those who love it, but add to its power and charm. The intense blacks of leads and stay-bars are ideal settings for the jewel-like color and lustrous whites of a well-composed window.

Nowhere is this more apparent than in the masterpieces of the twelfth and thirteenth centuries, when the difficulties which faced the artist and craftsman were so largely in evidence. Glass was made only in small pieces, the palette was limited, and it was well-nigh impossible to match colors accurately in different pots. Naturally, too, many mistakes were made in attempting various colors, so that instead of being lured into mechanical repetition, or staid and scholarly formulae, the maker of windows was kept vivid and fresh, and "being bound in the flesh, was set free in the spirit."

Consider any one of the rich treasures of Chartres, of Bourges or of Rheims. Many of its rare virtues are to be traced to these very limitations. Of course their value was in a sense negative, and without the propelling force of a genius for relatively perfect expression in color, no worthy result would have been achieved. The important point is, that with later improved facilities, when the artist was no longer "hampered" by such limitations, he was led far afield, and left the glories of that day for the polished and inept trivialities, the mechanical and tiresome accuracies, with which we are all too familiar.

It is useless to attempt to discount the achievements made in the production of any material for which there is a legitimate use. The enlarged palette and other increased facilities, offered to the artist who works in glass, should be encouraging and enlightening, rather than confusing.

Results are disastrous only when, tempted by an almost unlimited range of color, and by an alluring array of devices to disguise the rugged verities of his craft, he forgets the principles on which it is founded.

These principles could not be stated more clearly or more accurately than in the following words from the "Vitrail" of Viollet le Duc:

"What have been lost or forgotten during many centuries are the true manners which alone are suitable to painting of glass; manners dictated by study

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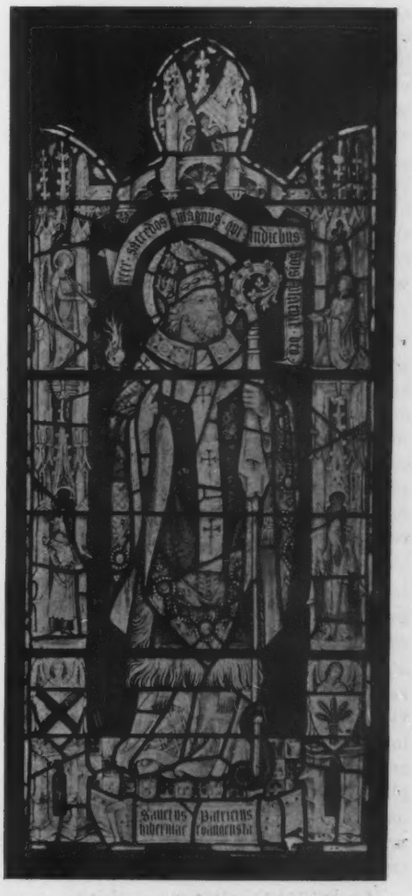


MODERN STAINED GLASS
Window in Saint Ferrer's Church, New York, designed and made by the Author

THE WORK OF A PHOTOGRAPHIC RESEARCH LABORATORY

By C. E. KENNETH MEES

Head of Department of Research Development, Eastman Kodak Co., Rochester, N. Y.

The Research Laboratory of the Eastman Kodak Company was established in 1912 to study the problems involved in the production and use of photographic materials.

Photographic research occupies a somewhat unique position in the field of applied science both because photography is so much used in other scientific work that interest in it is very widespread and because the methods of photographic research are so different from those of all other branches of scientific work that it is rare for the professional scientific man to understand them.

Very little work on the theory of photography has been done in the universities and there are perhaps three reasons for this: In the first place, information with regard to the theory of photography is not easy to obtain; there are few books on the subject and these deal generally with only a limited part of the field, and the original papers to which recourse must be had for information are scattered through a wide range of photographic and other journals. In the second place, work on the theory of photography necessarily involves work with photographic materials, and these materials are now made entirely by manufacturing companies, the methods of manufacture not being disclosed, so that the actual nature of the photographic materials themselves is but little understood by the user of them. In the third place, the apparatus required for photographic research is very specialized and somewhat expensive.

Our knowledge of photographic theory we owe chiefly to enthusiastic amateur photographers, supplemented in recent years by the research done by the photographic manufacturing firms, and it was in order to produce a considerable increase in the amount of this specialized photographic research work that the Eastman Kodak Company established its research laboratory.

The work of the laboratory deals, of course, not only with the theory of photography but with many points of practical importance both in the manufacture of photographic materials and apparatus and in their use. The laboratory is divided into different sections corresponding to the general divisions of science, notably physics, chemistry, and practical photography, the workers in these divisions collaborating in investigation of the problems with which the laboratory is concerned.

The branches of science which are of chief importance in photographic problems are those of optics in physics and of the colloid, physical, and organic divisions of chemistry.

Optics deals on its geometrical side with the materials used in photography —cameras, lenses, shutters, etc.—and on its physical side with such materials as color filters and illuminants, but especially with the study of the relation of the photographic image to the light by means of which it was produced—a study which is known by the name of sensitometry.

The manufacture of the sensitive material itself, which in the case of modern photographic plates, films, and paper is called the "emulsion," is a province of colloid and of physical chemistry, colloid chemistry dealing with the precipitation and nature of the sensitive silver salts formed in their gelatine layer, while physical chemistry informs us as to the nature of the reactions which go on, both in the formation of the sensitive substance and in its subsequent development after exposure.

The organic chemist prepares the reducing agents required for development and the dyes by which color sensitiveness is given to the photographic materials and by which the art of color photography can be carried on, and while the physicist therefore deals with sensitometry and the theory of exposure, the chemist must deal at the same time with the theory of development and with the conditions relating to the development of photographic images.

A laboratory, therefore, for the study of photographic problems must be arranged with a number of sections. There will be physical departments, dealing with sensitometry and illumination, reflection and absorption, colorimetry, spectroscopy and geometrical optics. There will be a department of colloid chemistry, one of physical chemistry, one of organic chemistry, one of photochemistry to deal with the action of light upon a plate, and finally a number of photographic departments, dealing with photographic chemistry, with portraiture, color photography, photo-engraving, motion picture work, and X-ray work, and the results obtained in all these departments will be applied first to the theory and then to the practice of photography.

In order to concentrate the different departments of the laboratory upon the photographic problems that arise and to ensure that on each problem the full knowledge and experience of the different specialists is made available, the main lines of work under investigation are discussed at a morning conference at the beginning of the day's work, one day of the week being assigned to each special subject, so that on Monday, for instance, those doing work in relation to one subject meet; on Tuesday the same men or other workers discuss a second aspect of the work of the laboratory, and so on. The laboratory organization, then, resolves itself into these several groups, interlocked by their common members, who are dealing with a number of different lines of work.

The work of the laboratory is published in the form of scientific papers, these being printed in the usual technical journals to which the special subject of the paper may be appropriate, and then, at intervals, as sufficient papers accumulate, full abstracts of all the papers are collected and published in a volume under the title of "Abridged Scientific Publications." At the time of writing, about 120 papers have been completed.

The scientific work of the laboratory can be classified under the headings of the physics of photography, the chemistry of photography, the reproduction of tone values by photography, and work on special photographic processes, including those required for photography in natural colors. In addition to this a considerable amount of research has been done in pure chemistry and in the various branches of applied optics which are closely allied to photography.

The Physics of Photography

Photographic sensitive surfaces do not consist of continuous coherent films of homogenous material but have a definite granular structure, the sensitive material itself consisting of grains embedded in an insensitive matrix, so that in considering the properties of a sensitive photographic material we are considering really the properties of a collection of sensitive grains, which may differ considerably from each other in their individual properties. The properties of such a collection will be the statistical average of the individuals composing it and in order to understand the properties of a sensitive material we must therefore consider the properties of the individual grains and their relation to the aggregate material of which they are units.

The question at once arises: Do these grains consist of crystals of pure silver halide or of a gelatine silver complex? Microscopical study shows it to be probable that the grain is a pure silver halide crystal, for when these crystals are exposed to the action of water no swelling at all is observable even under the highest power of the microscope. The grains of silver bromide prove to be regular semi-transparent crystals belonging to the isometric system, occurring chiefly

in triangular and hexagonal tablets and in needles of various thicknesses, these needles being formed in the same way as the tablets. As they occur in a gelatine emulsion, these grains are doubly refracting, though this would not have been expected from their crystalline form.

When the silver halide grains are developed, the crystalline form is lost, the silver being deposited in a sponge-form in soot-like particles, the form of the deposit being generally considerably distorted from the original shape of the silver bromide crystal grain, though in some cases the original shape is fairly well reproduced in the deposit of metallic silver.

In viewing a negative by transmitted light we can not, of course, see these isolated grains with the naked eye, but we see a conglomeration caused by the penetration of light through the interstices between the grains distributed throughout the emulsion layer, and thus we obtain regular large patches or chains of grain, the pattern and regularity depending upon the particular type of emulsion used. This granularity, the formation of which can be studied by the examination of a vertical section through the film, is what is meant by the "graininess" of photographic negatives in general and is the grain met with in enlarging, in projection, and in portraiture.

The granular structure of a photographic emulsion involves a limit to the resolving power of the emulsion; that is, it requires a certain finite distance between two points of light falling upon the film in order that they may record themselves as separate deposits of silver grains. The study of the resolving power of a photographic emulsion can be accomplished by the examination of the spread of the edge of an image. Suppose, for instance, that we lay upon a photographic film a knife edge and then illuminate this knife edge vertically from above; some of the light passing the knife edge will be scattered into the shadow by reflection from the grains of silver bromide and will produce developable grains within the shadow so that upon development we shall obtain a distinct extension of the image beyond the edge into the shadow. If we determine the relation between the number of grains rendered developable and the distance from the edge, we shall have a relation which will depend upon the scattering of the light by the silver bromide grains and upon the absorption of that light by the grains. These two factors we might term the "turbidity" and "opacity" of the emulsion.

An emulsion having high turbidity and low opacity will have a very low resolving power. On the other hand, even if the emulsion has high turbidity, if its opacity is also high, the resolving power may be good. A typical example of this is the wet collodion plate, in which the turbidity is considerable but the opacity of the silver iodide for blue-violet light is so great that the resolving power is high. In the grainless Lippman emulsion the resolving power is high if the emulsion is very clear because the turbidity is very small, but the opacity is also small so that the slightest increase in turbidity may make the resolving power very low.

A convenient way of measuring the resolving power is to photograph a converging grating, observing the point in the photograph at which resolution first occurs, from which a numerical measurement of the resolving power can be obtained.

The importance of photographic resolving power in relation to many branches of scientific work and especially spectroscopy and astronomy is obvious, and much work is being done in the laboratory upon these applications.

The study of the relation between the exposure of the photographic material and the blackening produced after development is generally termed "sensitometry," since this study was first undertaken by Hurter and Driffield in 1890, in order to determine the sensitiveness to light of photographic plates. The blackening is stated in terms of the optical density which is proportional to the mass of silver present in a unit area. The photographic material, plate, or film is given a series of increasing exposures so that after development a number of steps of density are produced, each step corresponding to a certain level of exposure. The density is then measured optically and plotted against the logarithm of the exposure by which means a curve is obtained which for the greater part of its length is a straight line though at the beginning and end it departs from rectilinearity. The curves obtained in this way are known as the "characteristic curves" of the material.

At the beginning of the curve, in what is termed the "period of underexposure," the density increase grows until it reaches a maximum, corresponding to that of the straight line portion where the increase of density is proportional to the increase in logarithmic exposure, and at the top of the curve in what is termed "the period of overexposure" the increase of density lessens until finally the density becomes constant. This constancy continues for a long period after which reversal sets in.

Inasmuch as emulsions are not homogeneous, but each emulsion contains grains of all sizes and of varying sensitiveness, the shape of the curve will depend upon the distribution of the different sizes of the grains in the emulsion. With a homogeneous emulsion we should have a simple curve with short over- and underexposure portions, and by adjusting the sizes of the grain so that there is a sufficient distribution of smaller and larger grains around the mean size we can diminish the size of the underexposed portion and obtain a longer straight line portion to the curve.

The Chemistry of Photography

While the grain structure of the emulsion and its reaction to light must be considered a branch of physics, the development of the emulsion is certainly closely related to physical chemistry. One of the most interesting pieces of

(*Continued on Page 123*)

VIEW OF KODAK PARK
Research Laboratory Buildings in the Left Foreground

THEORIES

By DR. WILLIS R. WHITNEY, '90

Director of Research Laboratory, General Electric Co., Schenectady, N. Y.

"I want to have agreement as to what I mean by theory. It may be that scientists have become hardened to a special use of the word. So I define theory as mental concept, as distinct from practice, which is always material. But for the scientist the combination of these two is necessary. They may be antithetical but they are not antagonistic. As allies, they are invincible. A theory is a means of satisfying the mind, when, for sake of economy, order, and mental increase, various thoughts first form into a conjecture, then into an hypothesis, and then into a full-grown theory. There is always a process concerning some selected group of apparently related observations. A theory is a kind of God-given group of accretive mental records, a sort of map, being made in more than three dimensions. It is like a promise, in that it is nearly nothing when taken alone. One's natural tendency is to attribute to it as little negotiable value as to an unendorsed note. I wish to show that there is warrant for our instinctive appreciation of theory in science. Even unproved theories have value, and the value consists in something more than the pleasure the theorizing process gives to the theorist. A theory is more than a systematic generalization furnishing the most satisfactory account and a rational explanation of things, because it is always an incentive for further experiment. It is more a gathering of forces preparatory to a jump.

"Probably no theory has had a longer life, or shown more valuable results, than the atomic theory of the chemist. That is a product which dates from the mythical past, but no chemist can practically get along without it. Chemical understanding is built upon it. If it were nothing more than a system which enabled us to remember better the countless facts of our science it would be well warranted. But, like almost all theories, it has enabled the chemist to prophesy and to produce. It has also led to extensions in kind, so that today we are recognizing that electricity must be added to our atomic theory, and that, through the combination, there comes an added systematic arranging of myriads of facts which the original atomic theory and separate electrical theories never contemplated. This in turn permits of still more prophecy and experimenting.

"Shall we undervalue unproved or wild theories, such as that which bears on the enormous source of energy sometime to be made available through atomic disintegration (a theory of Soddy's)? Certainly not! How, then, may we distinguish the God-given from the earth-born conceptions? There may be no *a priori* way, but there are two ways which are usually successful. One is to see if the theory originates in someone who has actual understanding contact with the matter in hand, and the other lies in the application. This is simple and mundane, and is again merely the working of close family relationships illustrated by the Metheus brothers.

"The value of some guiding theory is shown in countless cases of human advance. Perhaps as interesting and useful a case as the atomic theory of matter is that early conception quite antedating history, that a close relationship exists between the attractive effects of a rubbed piece of amber and the magnetic power of the lodestone. This has led to countless experiments, and the relationship—now much more clearly seen—is utilized in almost every form of electrical device. Perhaps the theory never caused amber to be more attractive nor the lodestone itself to be more true, but these two are forgotten because of the motors and generators, the telegraph and telephone, and all other electrical devices which the theory produced.

The value of theoretical knowledge was emphasized in an address entitled, "Theories," delivered by Dr. Willis R. Whitney, of Schenectady, New York, a research chemist connected with the General Electric Company, before the international meeting held at the College of the City of New York under the joint auspices of the American Chemical Society and the Society of Chemical Industry of Great Britain. As theoretical knowledge forms a large part of the instruction at Technology, this article will be of interest to all Tech men.

"We have all recently received a letter from President Smith, describing the serious need of the dye embargo bill and of helping congressmen to understand the magnitude of the danger we run. This is a practical matter. 'England, France, Italy and Japan have already safeguarded their dye industries.' The dye industry is the key to present and future explosive and munition developments, and promises to remain basic for future agricultural fertilizer undertakings. It is behind all research in medicines, deadly gas warfare, etc. It is not so much the value of the colors, but a much more extensive interest which concerns us. What has theory to do with that? Just this! The world owes the present stand of organic chemistry to a beautiful combination of theory and experiment. We now see it plainly in this industrial situation. In 1856 Perkin produced the first artificial dye. At that time, Kekule was theorizing, and he then laid the foundation of all our modern structures. His theories, which soon led into the wonderful conception of the benzene ring, are now the A B C of the dye industry. I can't refrain from pointing to the value of theory in this case, nor from adding that there is a lot of similarity between the taking apart and putting together of a clock and all of the work which Kekule and his followers have done. Most of the greatest nations of the world are still fighting for portions of the product of organic chemical theory.

"I wish I might illustrate the justifiable interest we naturally take in new theory by citing more of the countless cases which have broadened our horizons. Note how a theory opens the way for new work. It was long ago written that men loved darkness rather than light because their deeds were evil. For years good willed people have hoped that cause and effect were here somehow mixed. How much more interesting and useful may be the Loeb theory which has been tested on lower animals and plants. It is that the action of light on growing, living matter obeys the Bunsen-Talbot law, and is proportional to the product of time and intensity of the light which produces the chemical products necessary to the processes. The very action of such creatures in turning towards or away from the light is brought about by reaction products of light itself. This constructive theory calls for many new experiments, and who can know but that the ancient saying quoted above may be revised? There will be no evil when all get sufficient light.

"No great change in the habits of mankind is suggested herein, but possibly we do not always see how valuable is the more or less artificial condition which is created in a really very few places in the world, as was done in organic chemistry, for example, where, free from many of the immediate requirements of utility, an individual may produce new theories and facts. I say produce deliberately. Prometheus produced fire, so far as we are concerned. True, he may have stolen it from the gods. But just so, with the production of magnetism or the effect of steam, until produced by the first man, they had remained locked in our unknown, where there are still countless other things yet to be produced."

Pineapples are made to yield calcium citrate, alcohol, and sugar as well as marketable canned fruit when treated by the methods employed at modern canneries.

PROFESSOR CECIL HOBART PEABODY

By PROF. GEORGE OWEN, '94

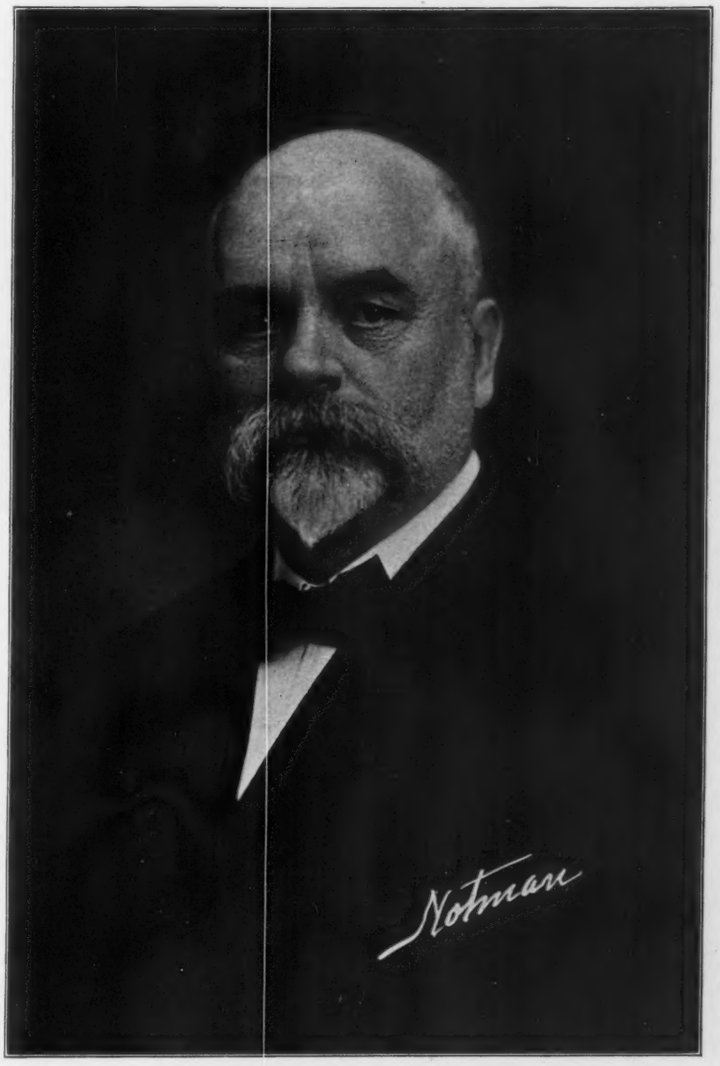
Professor of Marine Architecture, Massachusetts Institute of Technology

It is always a duty of the newcomer at the Massachusetts Institute of Technology, whether among the instructing staff or of the student body, to inform himself of the characters of those who have contributed towards the present greatness of this Institute. Among the class graduating in 1877 was a Vermont born boy—Cecil Hobart Peabody. Immediately on graduating, young Peabody, believing in Horace Greely's advice of "Go West, Young Man," went to Sapporo, Japan, where he taught mathematics to the Japanese and was so successful that he was there made Professor of Mathematics at the Imperial Agricultural College in 1878. Shortly afterwards he returned to his native country and took up the teaching of Mechanical Engineering at the University of Illinois, where he became Assistant Professor in 1881. In 1883, Professor Peabody was called back to his Alma Mater where he was installed as Associate Professor of Steam Engineering.

In 1893, when the course in Naval Architecture was established at the Massachusetts Institute of Technology, Professor Peabody was placed at its head as full Professor. In that year ship-building was at a very low ebb in the United States and many were the misgivings as to the wisdom of trying to maintain a course at the Institute for the professional training of Marine Architects. Professor Peabody, however, with the boundless faith and courage, which are so characteristic of him, promoted and upheld the dignity and integrity of his course in Naval Architecture against all critics and many times against great odds.

For several years, because of the dubious business outlook, the number of students taking the course dwindled. Maintenance appropriations were difficult to obtain and for a period it seemed as if the course would have to be abandoned. But Professor Peabody so successfully steered his good ship over the shoals of adversity that the course of Naval Architecture of the Massachusetts Institute of Technology finally became permanently established and is now recognized as one of the best in the world.

Professor Peabody's sterling personality brought him friends such as the late Dr. Chas. G. Weld, the late General Chas. J. Paine, and Henry A. Morss, whose aid enabled him to conduct many experiments relating to Marine Engineering that have since proved of much value to the profession. Notable among these were the experiments with the "Fulton" and "Froude," and steering gear trials on the revenue cutter "Manning." He has often made valuable scientific contributions to the American Society of Naval Architects and taken a prominent part in that Society's discussions.



CECIL HOBART PEABODY

In addition to his work at Technology, he has served as President of the "Board on Life Saving Appliances at Sea" from 1894 to 1900.

On the entrance of the United States into the World War, Professor Peabody and his Course came into their own. The United States suddenly found itself in desperate need of Naval Architects and Professor Peabody found himself beset on all sides by applications for admission to his classes. How well he met this emergency the Institute of Technology and the United States Government records show.

In addition to his regular administrative and instructing work in his course in Naval Architecture, during the War Professor Peabody filled the following executive positions:

President of the Academic Board, U. S. School of Military Aeronautics; President of the Academic Board, Naval Aviation Detachment; President of the Academic Board, School for Inspection Naval Aviation Detachment; and he had charge of the School of U. S. A. Aeronautical Engineers.

At different times during his career, Professor Peabody wrote and had published the following professional books: Thermodynamics of the Steam Engine; Tables of the Properties of Saturated Steam; Valve Gear for Steam Engines; Steam Boilers (with Professor E. F. Miller); Naval Architecture; Manual of Steam Engine Indicator; Thermodynamics of the Steam Turbine; Propellers; Computations for Marine Engines.

Professor Peabody is a Fellow in the American Academy of Arts and Sciences, a Vice President of the American Society of Naval Architects and Marine Engineers, and a member of the University Club of Boston.

In 1912, the Imperial Japanese Government conferred upon Professor Peabody the Imperial Order of the Rising Sun, 3rd class.

(Continued on Page 132)

ADVANTAGES OF RAILWAY ELECTRIFICATION

By W. D. BEARCE

Statistician, Railway and Traction Department, General Electric Co., Schenectady, N. Y.

The first heavy railroad electrification was that of the Baltimore & Ohio R. R. in 1895. At this time the advantages of railroad electrification were largely hypothetical, since there was no practical example in operation to verify the claims of its advocates. Since that time, however, numerous installations have been made covering the entire railroad field beginning with tunnels and suburban traffic zones, followed by electrification of interurban lines, switching yards and finally main line transcontinental divisions. As a result of this varied experience it is almost universally recognized that there are many advantages in the electrical operation of railroads over the more commonly used method of steam haulage.

These advantages may be grouped according to their relative weights under three heads.

Reduction in operating expenses.

Improved operating conditions.

Intangible assets.

The first group is the most important of the three and since the railroad operator is primarily interested in profit and loss these reasons carry more weight with a steam road official than either of the others. Unless electrification pays in dollars and cents, he cannot be interested. This applies, of course, where no other factors enter into the case, such as legislative requirements, smoke limitations in tunnels or congested conditions of traffic which are caused by limited terminal areas. Under conditions of this character some of the other advantages become more important than financial considerations.

Reduction in Operating Expenses

One of the most important advantages of electrification is the saving in the cost of power. The cost of coal and fuel oil for the operation of steam railroads is an enormous figure and in recent years the soaring prices have made this factor still more important. Electricity, on the other hand, can be purchased at a fairly reasonable rate and under contracts extending over a long term of years. For example; the C., M. & St. Paul Railway has a contract for 99 years at a rate of between five-tenths and six-tenths of a cent per KW. hour. This figure is based upon hydro-electric energy. Very reasonable prices, however, can also be obtained in sections where only steam generated power is available. It has been conservatively estimated that the amount of coal required for electric operation of all our railroads would be only about one-third that required for steam operation.

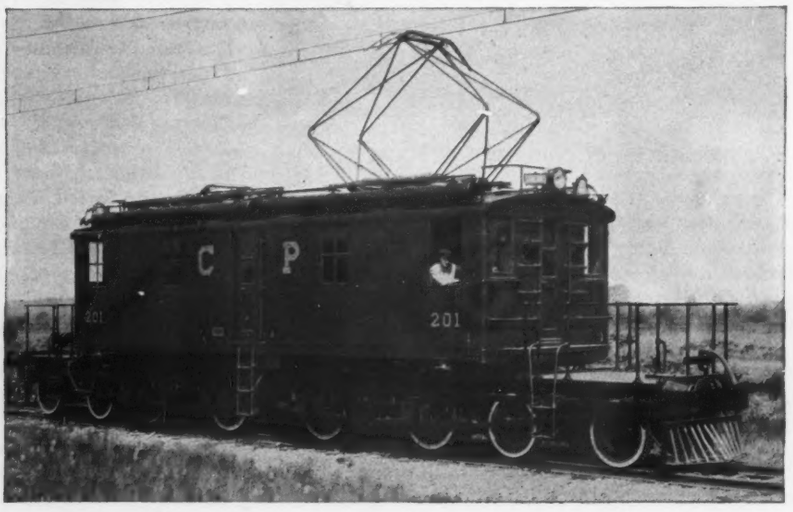
Closely allied to this factor is the reduction in the cost of operation secured by the elimination of numerous coal pockets and water tanks, which are indispensable to the steam railroad. These accessories constitute a heavy operating and overhead expense. It has been estimated that the facilities required by the steam railroads for the care and maintenance of the steam locomotive, covering fuel and water stations, shops and engine houses, shop machinery, turn tables, etc., amount to more than sixty per cent of the cost of the locomotives themselves.

Another heavy expense connected with steam locomotive operation is the transportation of company coal (and water in some cases) from the point of purchase to the various distribution points. Under electrical operation this expense is practically eliminated. Recent examples have also indicated that appreciable savings can be made by the elimination of terminal shops and round houses which are no longer necessary under electrical operation. This saving is due to the larger cruising radius of the electric locomotive. The maximum division length under steam operation is from 100 to 150 miles, whereas electric locomotives are now being operated from two to four times this distance. As a matter of fact even this figure does not represent the maximum capability of the electric locomotive.

Another important advantage of electrical operation over steam is the reduction in the cost of labor. This saving is due to the higher speed and heavier capacity of the electric locomotive. Experience has also shown that the electric locomotive operates with fewer delays. The net result of these items is a reduction in the cost per ton mile of traffic moved over a given system.

260 TON GEARLESS LOCOMOTIVE
Hauling a passenger train in the Cascade Mountains, Washington

A most important item of saving under electric operation is in the maintenance of electric locomotives and other rolling stock. The cost per locomotive mile is conservatively estimated at not less than one-third of that required to maintain steam locomotives, assuming, of course, equivalent hauling capacity. In regard to the maintenance of other rolling stock such as passenger coaches and freight cars, figures are not available for an actual comparison, but it is well known that the rough handling of this equipment by steam locomotives is the cause of frequent damage to drawheads, trucks and superstructure. On the other hand, the electric locomotive is capable of starting its train from rest without shock. A further advantage is obtained on grade divisions by the use of the regenerative braking feature which relieves the air brakes of destructive service on long down grades and at the same time returns energy to the line for the assistance of other trains requiring power. While the saving of energy is considered of small import compared



3000 VOLT D. C. PASSENGER LOCOMOTIVE
Built for the Paulista Railway, Brazil

to the freedom from destructive shock and damage to brake shoes and wheels, this saving is nevertheless worthy of note. On the Chicago, Milwaukee & St. Paul Railway, Rocky Mountain Division, tests over a long period indicated that approximately 14 per cent of the energy required for traction is returned to the line in the form of regenerated power. Another item of saving which is not easily measured is the reduced wear and tear on the track. There is no question, however, but that the maintenance of the track is reduced by the elimination of

125 TON LOCOMOTIVE
Hauling a New York Central train

counterbalanced wheels and reduction in the amount of mechanical braking. Tests have been made by the American Railway Association which indicate that the impact from electric locomotives on structures exceeding 25 ft. span is not more than one-third of that produced by steam locomotives.

Improved Operating Conditions

Under this heading there are a number of items which may be mentioned in the discussion of the relative advantages of steam and electric locomotives. It is not usually possible, however, to take any definite measure of the advantages accruing to electrical operation because of these points of merit.

An important point which has been mentioned above in connection with reduction in capital expense is the elimination of coal and water facilities. It is evident that a further saving will be obtained by electric operation, due to the elimination of delays in taking coal and water. There are, of course, many roads in this country and other parts of the world operating steam locomotives through tunnels of considerable length. While such operation is possible with special fuel and locomotives, it is of undoubted advantage to be able to eliminate the heavy expense and the hazards which are unavoidable with the operation of steam locomotives through tunnels. In fact a number of roads have considered it of sufficient importance to spend large sums for the electrification of tunnels alone.

Another point of advantage is the uniform improvement and greater reliability in the performance of schedules. Passenger trains are delivered at their terminals more uniformly on time; freight is transported between terminals on better schedule. This condition applies especially in cold weather when it is difficult to maintain the capacity of steam locomotives.

Intangible Assets

There are a number of other advantageous features of electric railway operation which are of an intangible nature and cannot be capitalized. They are nevertheless recognized as being of great value and should be considered in debating the relative merits in steam and electric haulage. The first of these is cleanliness. The freedom of dust, soot and cinders should be sufficient argument in many cases to influence patronage on passenger trains. This is especially true on long runs with observation equipments through scenic country. Another point is a greater comfort obtainable in electric haulage. Many of us have observed the ease with which an electric locomotive starts its trains. There is no violent shock and the train sometimes gets under way before the passenger is aware that it is in motion. On heavy mountain grades with regenerative braking the train is easily lowered down the hills without the use of air brakes. The accompanying application and release of the brake shoes causing an alternate speeding up and slowing down of the train is especially disagreeable. The reduction in the number of stops for taking coal and water also eliminates other rough handling, due to breaking up and re-making the train.

In connection with regenerative braking there is also the factor of greater safety due to the duplicated system of brakes and the uniformly steady braking effect. The ordinary air brake equipment is thus held in reserve for emergency service. Since this equipment is not used to any extent for heavy duty on the grades it is more likely to be in good condition when required for emergency service.

Another asset not ordinarily considered is the advertising value of electrification. Numerous points which have been mentioned herein citing the relative advantage of electric haulage over steam may be used to advantage in advertisements for passenger and freight traffic; thus increasing the volume of business.

In connection with some terminal properties there has been considerable enhancement of real estate values, both to the property of the railroad company and the surrounding land. This factor should not be overlooked especially where the amount of space available for tracks and terminal buildings is limited.

And lastly we should not forget that most important asset, the conservation of our natural resources by saving in coal and oil, which is required for fuel. While this argument cannot be used to interest railroad operators it is nevertheless worthy of consideration from a national standpoint. Not including the saving due to the use of hydro-electric power it is estimated that the saving in coal by the universal electrification of the railroads of the United States would be not less than 100,000,000 tons per year.

ELECTRIC INTER-URBAN EQUIPMENT

OUR FUTURE SUPPLY OF IRON

By H. R. ALDRICH, '14

Chief of Field Parties, State of Wisconsin Geological and Natural History Survey

"The world will never run short of ores for producing iron, although it may reach the end of the rich ores such as we now think we cannot get along without."[1] Whether faith, fancy, or fact, this is the opinion of an eminent metallurgist. Is it an expression of faith in a benevolent Providence to provide, or a fanciful idea that miracle workers of science will rise to any threatening occasion with a method for transmutation whereby a less worthy substance may compensate for the exhaustion of our iron stores? This paper makes no pretense of proving the fact of the matter, but demonstrates the tendencies operative even today against the possible future day of depletion of "rich" ores.

That part of the earth's crust to which man has access has been estimated to contain about 5% of metallic iron. Among metals, iron ranks third, with silicon and aluminum surpassing it in natural abundance. Despite this plenty, however, the iron is widely distributed through the rocks. Select any considerable rock mass and it contains iron, although it may be of low proportion. Furthermore, the rich ores analyzing just short of 70% iron are but infinitesimal parts of the entire crust. To picture this distribution, suppose it were possible to canvass the entire globe, map every rock mass having the size of one of the masses now productive of iron ore, and to determine the iron content of each. Assume for convenience in discussion that we have listed ten thousand such masses, and having arranged these in decreasing order of their iron content, we could erect on a sheet of paper ten thousand vertical columns side by side with the vertical height proportional to the iron content of each rock. Through the upper end of these columns we might sketch a curve depicting the distribution of iron, world wide, in terms of rock masses. What would be the shape of this curve?

Pure metallic iron does not occur in nature in masses as great as we have chosen. It only occurs in compounds with oxygen, or some other element in the form of minerals. The five most common iron minerals to be considered are:

Magnetite, containing 72.4% iron.
Hematite, containing 70.0% iron.
Limonite, containing 59.8% iron.
Siderite, containing 48.3% iron.
Ilmenite, containing 36.8% iron.

Each of these may constitute the entire mass of any rock. Consequently, our curve will start at the upper end of a column representing a mass of pure magnetite. Since there are many such masses, our curve will show a terrace feature at this height, and similarly there will be terraces for each of the remaining four minerals. Between terraces, due to mixtures, there will be smooth curves, and from 36.8% the curve will slope away toward the zero line.

Estimates have been made that the "rich ores such as we now think we can not get along without" constitute reserves to supply industry not longer than the next fifty to seventy-five years. Granting this, that "the world will never run short of ores for producing iron," where are we to seek the ores for one hundred years hence? Where, on our curve, will these be found?

To reply to this question, consider first a curve similar to our hypothetical one, but built upon the data available, which is obviously incomplete; and compare the two. It is not at all unlikely that a striking discrepancy will be found in the terraces because of the fact that we have not yet discovered all the masses of these rich ores. We may conclude, therefore, that one promising field in which to search for ores to satisfy the demands of industry is in these regions of the curve. Another outstanding demonstration will be the great store of iron withheld from utilization in the titaniferous ores, which are not, now at least, amenable to our metallurgical processes. A third object lesson will be the abundance of iron contained in rock masses which are not of direct use to the smelters because of their low grade, but which offer opportunities for investigation in the segregation of the minerals which, by themselves, are of value.

These three avenues offer the approach to the source of iron for future generations:

1. Discovery of new deposits of pure, easily reducible, iron minerals.
2. Discovery of new processes for reducing refractory iron minerals from large deposits, such as the ilmenites.
3. Discovery of new processes for segregation of iron minerals from associated minerals in the lower grade masses.

Investigation is under way seeking to accomplish the second problem, and the leading example of progress along the third avenue is the new enterprise on the east end of the Mesabi Range of Minnesota which has been reported in these pages.[2] The concluding paragraphs of this paper deal with a single phase of the attempts being made to advance along the first of these avenues. Before proceeding to these considerations it may be stated that progress may be made along any one of these lines independent of the others. While it is probably true that discovery of new, rich bodies of ore would be progressing along the line of least change in existing conditions, the solution of either of the two remaining problems would, in effect, mean the conservation of the more desirable rich ores. For example, on the Mesabi the rock being used runs as low as 20% iron, while the richer deposits are still held in large reserves.

Because of its magnetic properties iron ore provides its searchers with a means for exploring regions where visible examination of the rocks is an impossibility. It is no special advantage that this is true of the ores of no other metal, unless it be certain nickel minerals, and yet it is peculiarly significant that this is true of the metal that constitutes 95% of all the metals dealt with in commerce. In exploring for iron ore the two instruments known as the "dip needle" and "dial compass" are used. The dial compass is an ordinary surveyor's compass to which has been fitted a sun dial. When properly set up by the sun, any variation in the needle from the local magnetic bearing indicates the deformation of the earth's field due to a rock mass at no great distance. The variation of the dipping needle, which is pivoted horizontally, when read in the plane of the earth's field as established by the compass, is a measure of the strength of the local attraction, and an indicator of the location of the attracting mass. A thorough examination of an area with these instruments permits the mapping of areas containing a quantity of iron minerals greater than that of the average rocks.

As an example of the value of these methods in promoting the knowledge of the underlying rocks of the great Lake Superior Iron Region, the most striking is the work of Adams on the Cuyuna Range. The mapping and development of this field was controlled by the magnetic instruments. Furthermore, the Vermillion Range, and the east end of the Mesabi have been better understood because of the magnetic surveys. Most of the progressive iron producing companies of the whole district employ the same means for exploring ground over which they have control, or over prospective purchases.

If the complete history of the iron formations of the Lake Superior Region were known, it would be possible to eliminate barren areas from speculation and focus full attention upon the more promising areas. Lacking this, great areas

[1] J. W. Richards, A. I. M. E. Trans. 1919, p. 141.

[2] Tech Engineering News, December, 1920.

within which the possibilities of iron ore are considerable must be examined by magnetic methods; and, having done this, the engineer has narrowed the possibilities to the areas of magnetic attraction. Unfortunately, as far as the immediate purpose of locating ores is concerned, the method does not return positive information, because many rocks other than iron ores contain magnetite sufficient in amount to cause attraction. Although, to a certain extent, careful study of the characteristics of the attraction may reveal some indication of the type of rock under discussion, the diamond drill or test pitting are the only safe ways of determining the character of the rock. Even though these means may fail to disclose iron ores, the rock mass may be rich enough to merit consideration as a concentration proposition. Several such masses have been located within the State of Wisconsin.

The preliminary examination of any great area is beyond the present means of the private companies. The three States, Wisconsin, Minnesota, and Michigan, have in the past or are at present conducting a careful combing of the Pre Cambrian areas within which there are always iron ore possibilities. These State Surveys have been foremost among the forces active in promoting the extension of the known iron producing sections of the Lake Superior Region. There are great areas of magnetic attraction indicative of underlying rocks containing far more than average proportions of iron. An application of similar methods to other areas of the world would undoubtedly be the means of discovering deposits of iron for future generations. At least the methods will disclose those areas where the greatest chances exist, and will expose those masses to which research in concentration or metallurgy should be applied in preparing against the day of depletion of our rich ores.

THE MINING ENGINEER'S JOB

By GEORGE A. PACKARD, '90

Consulting Mining Engineer

Few professions offer such diversified opportunities as does that of the mining engineer. His training at Technology gives him an insight into the work of a half dozen other professions. The foundation is laid in the courses in mathematics, chemistry, and physics. The training in professional fundamentals includes mineralogy, geology, surveying, mechanics, electricity, as well as mining and metallurgy. All these are necessary that he may recognize the minerals in an ore, foresee the probable extent of its occurrence, make the necessary openings for its extraction, select the proper machinery for handling it, provide an economical power plant, and determine the best method of treatment. A knowledge of business law prepares him to see that contracts are properly drawn, and that titles are good. Sanitary science enables him to ensure healthful working places and camps. History and literature, coupled with a little experience as a laborer, help him to handle his men. A knowledge of good English and of political economy fits him to report concisely to his employers, and to understand financial conditions. The study of other languages permits him to keep informed on foreign scientific progress and to engage in foreign exploration.

With this broad foundation is it remarkable that we find mining engineers filling positions which seem strange to those unfamiliar with their preparation?

The man who enjoys chemistry, or perhaps by force of circumstances starts as a chemist for some mine or smelter, follows that line. Ultimately, perhaps, he opens an office in a large city and becomes an authority on methods of analysis. One '83 man thus became manager of a pulp mill and operated it for twenty years. A man who likes surveying becomes interested in railroad location work, or secures an appointment as a Deputy United States Mineral Surveyor, as have many mining engineers in the West. From this we find them taking up construction, bridge building, or the laying of sewer and water lines. Many mining machinery companies now endeavor to obtain engineers in connection with the design of machinery or as salesmen, who later hold important positions in charge of large branch offices. This offers opportunity to live in Mexico, Johannesburg, Berlin, London, as well as the large cities of the United States. One mining engineer is an expert designer of garages. One '87 man became prominent in the electrical world though he continued to give much attention to mining problems. Naturally, many have served as teachers and college professors.

These follow a normal development from the Technology courses, but others have gone much farther afield. For many years a mining engineer conducted an extensive law business in Mexico, at first developed in securing satisfactory titles to mining property. Other engineers have qualified as lawyers, and Dr. R. W. Raymond was permitted to practise before the Supreme Court. Another mining engineer became a physician.

One of our older Technology mining engineers, who first learned Chinese from his mining camp servant, and later had charge of work in China, became official interpreter for Li Hung Chang. Another, from acting as correspondent for a mining journal, has developed a successful business as publicity man for several railroads, preparing descriptions of the natural resources along their lines. His work extends from Canada to Mexico. One has written novels and several have published descriptions of their travels. Ingalls, '86, was for many years the successful editor of the greatest mining journal in the world.

Incidentally, as an avocation, two mining engineers are authorities on bird life and one on fishes of the South Pacific. Several have good incomes from processes developed in the course of professional work. Colonel DuPont is an example of a man who has turned his engineering knowledge to excellent account in many lines.

But the real job of the mining engineer is securing, developing, equipping and operating a mine, and preparing its products for market. The scout, looking for mining prospects for an exploration syndicate, "mushes" over the snow of Alaska, paddles the streams of Ontario, crosses the desert in an automobile, and rides a mule among the mountain passes of Mexico and South America. Following him comes the "examining engineer," and while he may visit some prospects in isolated locations, much of this work, as his experience makes him more valuable, is in larger camps. After him the superintendent, the manager, and the consulting engineer, carry on the development and equipment. If he is in a large camp like Butte or Bisbee or Johannesburg, conditions are as agreeable as in Albany or Atlanta.

Then comes the period of operation, when the task of the manager is to keep the work running smoothly, to find new ore bodies, to cope with the problems of increasing depth, and to cut off a cent here, a half cent there, from the costs, in order to stave off the period of decline as long as possible. No one enjoys this last stage, but it offers opportunity for ingenuity in the effort to prolong the paying life of the mine which the engineer has developed.

MANUFACTURE AND USE OF COATED ABRASIVES

By LEWIS S. GREENLEAF, '94

Vice-President and Treasurer, Manning Abrasive Co., Troy, N. Y.

Many papers have been published from time to time in the various trade journals on the manufacture of grinding wheels and their selection for various operations in different industries, but very little has been published along similar lines regarding the manufacture and uses of coated abrasives, by which term we mean abrasive materials in grain form cemented to a backing paper or cloth, or a combination of the two.

The average man, who has not had experience in the finishing rooms of manufacturing plants, seldom gets beyond the knowledge of "Sandpaper" and "Emery Cloth," but when it is realized that about one-half of the coated abrasives in use today are used on machines and to what extent the manufactured abrasives produced in electric furnaces are being utilized, an accurate knowledge of the process of manufacture of coated abrasives, their properties and uses becomes of considerable importance. In the manufacture of coated abrasives the principal abrasive materials used are quartz (commonly referred to as "flint"), garnet, emery, and artificial or electric furnace abrasives.

The quartz used for abrasive purposes is quarried from veins or deposits in various localities and must be of a hard, clear character, free of impurities. It is in all cases crushed and graded to sizes required. Nearly all quartz is made up on paper backing, and the largest part is sold in sheets 9x11 inches or 8¾ x 10½ inches. This is the usual sandpaper of commerce handled largely through the hardware and paint stores.

Practically all the abrasive garnet used in the industry is obtained from the lower Adirondack region of New York State, where it occurs in pockets in the rock, the pockets varying in size from an inch to a foot in diameter. The rock containing the garnet, which is of the almandite variety, is quarried and crushed, and the garnet separated from the rock on wet separating tables. The coated abrasive plants recrush this garnet and grade it through silk screens to the proper sizes for use.

While considerable garnet paper is sold in sheets for hand use, the bulk of it is made up on especially strong paper, cloth, or combination backing for machine use, and then is sold in 50-yard rolls. These rolls are from 6 to 48 inches in width for paper, and 6 to 28 inches for cloth and combination. Almost all garnet products are sold to manufacturing concerns such as furniture factories, sash and door mills, piano factories, etc., and are by far the most efficient coated abrasive for woodworking, especially on hard woods such as oak and mahogany.

Emery, which is impure Corundum, is mined principally in Greece and in Asia Minor, shipped to this country in rock form, crushed, and graded in the Emery Mills here. During the war the coated abrasive manufacturers were obliged to use American Emery which is not as efficient as the imported variety.

Most of the Emery is coated on cloth backing and sold in 9 x 11 sheets through the hardware trade or direct to metal working plants. While Emery is a satisfactory abrasive for a few purposes, it is being rapidly superseded for most metal working uses by the electric furnace abrasives.

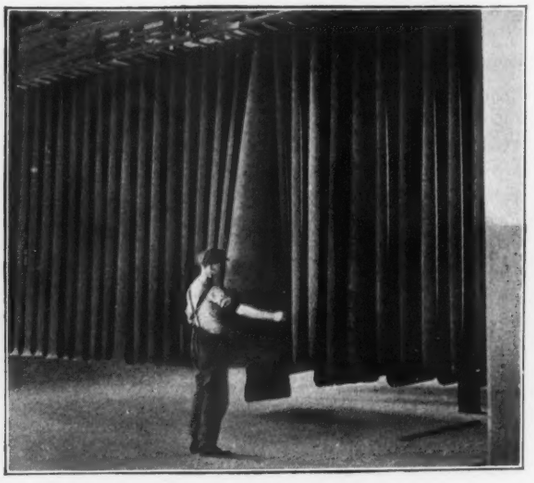
The so-called artificial abrasives are Aluminum Oxide, which is made by fusing Bauxite, thus producing practically an artificial Corundum or purified Emery; and Silicon Carbide, made from fusing Coke and Silica Sand which produces an extremely sharp and brittle abrasive, second only to a diamond in hardness. These abrasives are made by several manufacturers and marketed under various trade names, such as Alundum, or Exelon, and for Silicon Carbide—Carborundum, Carbolon, or Durite, etc.

The Aluminum Oxide abrasives, which are brown in color, are the most efficient metal working abrasives known, especially on hard metals. They are made up almost exclusively on cloth backing and sold to the manufacturing trades either in 9 x 11 sheets for hand use, in the form of belts for belt sanders, or in discs for disc grinders.

The Silicon Carbide abrasives, which vary from a green to a blue-black color, are the most efficient for use on leather, very soft metals, hard rubber plastics, and composite material. Thus this material is almost universally used in shoe factories. It is made on paper backing and sold in sheets or rolls, on cloth or combination backing for use in moulded shapes on shoe buffing wheels, and in the form of belts and discs.

In the preparation of abrasive grains for use, the most important feature is the accurate grading to size. For flint, garnet and emery products and for those artificial abrasive products made with Aluminum Oxide, which compete with emery, the designations used in the industry are 4/0, 3/0, 2/0, 0, ½, etc., up to 3½, ranging from fine to coarse. The size grains for these different designations are entirely arbitrary, established by long usage, and are not always the same, i. e., they may vary between different manufacturers and are not the same for the different materials. For instance, all manufacturers may agree

BELT-GRINDING DIE COLLETS



DRYING LOOPS OF ABRASIVE PAPER

that for No. 1 flint the control screen shall be No. 24, this being an arbitrary designation for a screen of a certain number of meshes to the inch. The ideal grain will be that which will not pass through the next finer screen, say No. 25, and that will all pass through the No. 24, no grains failing to pass through it.

In practice this condition is never reached, but the standards to be followed are set up by each manufacturer, all having agreed on the control screens. For instance, A may set up a standard such as for No. 1 flint, 5% through No. 25 screen and 95% through No. 24 screen, none over No. 24, while B may adopt 25% through No. 25 screen, 74% through No. 24 and 1% over.

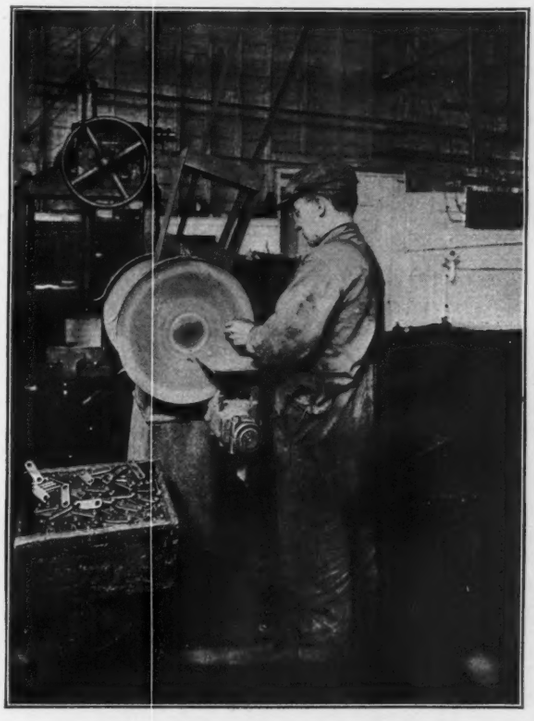
The standards or control screens adopted are not the same for flint, garnet and emery, No. 1 garnet being coarser than No. 1 flint and No. 1 flint being coarser than No. 1 emery. The grading of the artificial abrasives is quite close to that of emery and the sizes are designated by the number of meshes to the inch of a screen through which the grain will pass. Thus No. 60 represents grains that will pass through a screen having 60 meshes to the inch and is equivalent to No. 2 Emery. While it is clear that the gradings of different manufacturers differ from one another, the variation is generally slight and for each manufacturer, his established grades are held very accurately to his standards.

The backing used for coated abrasives is of great importance and depends to a large extent on the use that is to be made of the finished product. For hand use, except on fine finishing papers, a light, strong paper is most satisfactory, while for belts or for paper used on drum sanders an extremely strong and heavy paper must be employed. The paper for this purpose is made from Manila fibre. Various weights of cotton cloth are used, Jeans, Drills, Twills and Duck, depending on the uses to which the abrasive cloth is to be put. All such cloth must be treated before coating to prevent the subsequent glue coating from being absorbed by the cloth. This treatment consists of filling the pores of the cloth with proper materials and on this process much of the success of the abrasive cloth depends, for if there is too much filler, the glue coating will not hold firmly to the thread, and if too little the glue coating will be absorbed, leaving not enough to properly anchor the abrasive.

The amount of abrasive per square inch is dependent on the strength of the glue solution used, which must be varied for the different sizes of grain, type of abrasive and character of backing. It is essential that the temperature be controlled as changes in temperature affect the density of the glue solution. High grades of hide glue are almost exclusively used.

The process of coating paper or cloth, which is done in rolls, consists of carrying the paper or cloth through a rotary printing press which prints the name, grit, etc., on the back of the sheet, thence to the coating machine where the paper runs between two rolls, one a rubber roll revolving in a trough of glue and transferring a coating of glue to the paper. The thickness of this coating is regulated by the separation of the two rolls. The paper then passes under a brush which has a rapid reciprocating motion which smooths the glue coating and then under a sand hopper from the bottom of which the abrasive material pours on to the paper like a waterfall. The paper is then pulled by a suction drum and fed on to the racks by an ingenious device which loops the paper on slats—the loops being about twelve feet in length. On the racks through a reciprocating device the slats are pushed ahead, and after travelling about 100 feet the paper is carried through a second or sizing machine similar to the first machine except that the brush and sand hopper is omitted. Through this machine the paper is given a second coating of this glue which thoroughly anchors the grains in place and from this the paper is carried on a second rack which extends back and forth throughout the length of the room. This rack will hold about six miles of paper and through a ventilating arrangement which permits the control of the humidity, the paper at the end of the room is properly dried. It is taken down from the racks by a winding machine which winds up the paper in large rolls of about 1000 yards, and varying in width from 22 inches to 48 inches, depending on the goods being run.

After the rolls of abrasives are made, the material is converted into the stock sizes by being cut into sheets, put into 50 yard rolls of various widths or made up into belts or discs.



DISC-GRINDING BRASS CASTINGS

ALUMNI

Mr. A. J. Manson '05 has recently been placed in charge of the Westinghouse Electric & Manufacturing Company's railway work in New York.

Mr. E. E. Winkley '91 of Lynn has invented a mechanism for controlling the course, speed, et cetera, of a vessel so that by previously adjusting the apparatus the vessel may be made to enter harbors, follow tortuous channels, and weave its way through mine fields without a human being on board. The device is not affected by wireless or similar outside interference, and it can be arranged in such a way that if the machinery is tampered with the boat will instantly blow up.

Commander Brownell of the U. S. Navy and Messrs. Norris and Grover formed the board of Engineers which built the Piscataqua River Bridge which we mentioned in October issue. This engineering feat was built by the Holbrook Cabot & Rollins Corporation.

Roentgen Ray Society Meets.—At a recent meeting of the American Roentgen Ray Society, Dr. W. D. Coolidge '96 told of the improvement on medical X-ray outfits to the extent that all danger of electrical shocks and burns has been eliminated, while, at the same time, the outfits have been rendered so compact that efficient models but little larger than a camera may be purchased. A specially designed tube is enclosed in an oil filled metal box and grounded so that the whole high tension system is safeguarded. The rays pass through an opening in the box and are focused by a rubber cone which may be placed next the skin if desired. The X-ray outfit is mounted on a stand and the only other device used is a small control switch, a transformer for adapting household current to the apparatus being included in the outfit.

MONTHLY NEWS

Huge Hangar at Scott Field.—The W. M. Sutherland Building and Construction Co. has been awarded the contract for the construction of a huge hangar for the Army Air Service at Scott Field, Illinois. The cost will be $1,043,000 and the hangar must be completed within 300 days. The hangar is to be 900 feet long by 200 feet wide, and 180 feet high. It will have four doors, two at each end, and will be capable of housing several non-rigid dirigibles or one mammoth ship of the ZR-2 type.

An Induction Motor with a double cage rotor and two distinct stators has been placed on the market by a German concern. Means are provided for controlling the speed without the use of resistance. Full details, including torque, efficiency, and speed curves of this motor are given in a recent issue of the *Electrotechnische Zietschrift*.

Test Baltimore Gas.—In order to determine what quality of gas will give the people of Baltimore the best service with the least cost to the consumer, the U. S. Bureau of Standards has begun an investigation of the matter in conjunction with the Maryland Public Service Commission and The Consolidated Gas and Electric Co. of Baltimore. Laboratory tests of the coke oven gas from Sparrows Point, of different qualities of water gas, as made at the Spring Garden station, and of mixtures of coke oven and water gas are being carried on by the bureau's engineers. To be able to state what is the most economical standard of quality, it will be necessary to consider the cost of manufacture and distribution of the various gases and their relative utilization efficiencies.

Captain Sir Ross Smith, who last year made a successful flight from England to Australia, will start shortly on a flight around the world, according to the London Daily Mail. He proposes, after crossing over Europe and Asia, to fly from Japan to Alaska, thence across Canada to Nova Scotia, and over the Atlantic to England.

An International Wireless Company for the control and development of the greater part of the world's radio facilities has just been organized by representatives of the principal radio interests of the United States, Great Britain, France, and Germany. The arrangement is the outgrowth of a desire of the four countries to place wireless on a sound commercial basis. The governments concerned approved of the conference and will probably back the organization which has been formed. Wireless facilities of the four countries have been pooled, each country retaining control over its own territory. It is thus hoped to eliminate the great waste occasioned in the past by duplication of equipment of the different companies and to place at the disposal of the international company unlimited funds for extensive programs of development and research.

Biggest Radio Station.—The largest and most powerful radio station in the world is now under construction at Port Jefferson, Long Island, and several units of the station are now in use by the Radio Corporation of America, a subsidiary of the General Electric Co. The station as a whole occupies an area of ten square miles on which are to be located twelve antenna systems which radiate from a central point at which is located a power house for producing the necessary high frequency current. There are six towers to each antenna set and the towers are spaced a distance of 1,250 feet, thus making each antenna approximately a mile and a half long. Sixteen phospor bronze cables serve as antenna wires, and are supported at a height of 350 feet. The Port Jefferson plant is to be used for sending only, the receiving station being located at Riverhead, some twelve miles away. The actual receiving and sending of messages will be from the company's offices in New York City. Current for the plant is provided by 25,000 cycle, 200 kw. generators, one for each antenna system. The use of multiple tuned antenna effects a great saving of power in the antenna system, so that theoretically this plant is thirty times more powerful than any other station in the world.

The Last Cornish Tin Mine has closed down and an industry which was the oldest in Great Britain, having been carried on by the Phoenicians long before the invasion of the Romans, is now extinct. The reason for the closure of the mines lies in the fact that the mining is no longer profitable owing to the low price of tin and the high price of coal and other necessary materials. It is estimated that 100,000 tin miners have been thrown out of work.

The Scout Cruiser *Richmond* was recently launched at the Cramps Shipyards, Philadelphia. The *Richmond* is slightly more than 555 feet long and is capable of a speed of 33 knots. She is 55 feet in beam at the waterline and carries a main battery of twelve 6-inch guns and two torpedo tubes. The *Richmond* was designed to be capable of the combined duties of scout cruiser, flotilla leader, mine layer, and airplane carrier.

Consolidate Government Science.—A plan for consolidating the various scientific bureaus of the government under the Smithsonian Institute has been presented to the joint committee on reorganization of Government departments by Arthur McDonald, scientist. The primary object of the plan is to have the scientific activity of the Government developed to its highest efficiency and, with this end in view, to correct the illogical arrangement of the present bureaus and to reduce political influence to a minimum. The plan would enable the Government to obtain the services of the best scientists in the country by insuring permanent tenure of office and nonmeddling of politics in their work.

The World's Largest Ship, the 912-foot, 56,000 ton *Majestic*, which will be ready for service between New York and Southampton next spring, bids fair to tax the capacity of the Port of New York to a breaking point. The New York piers, extended as they now are for the present ocean liners, will be a tight fit for the *Majestic*, and the task of getting her into her berth will present as big a job as the docking experts employed by the big companies have yet encountered. The task of berthing a large ship in the New York harbor is rendered very difficult by the fact that the docks are set at right angles to a river in which strong tides flow regularly.

A Tunnel Digging Machine, the invention of Milton R. Sheen, is creating considerable interest in Philadelphia, where it is being used in the construction of an underground conduit. The machine digs a tunnel, removes the earth, and places a concrete wall around the excavation almost simultaneously, leaving a finished tunnel in its path. The only necessary work required to start the machine is the digging of an excavation sufficiently large to accommodate it. The machine can be used in the construction of tunnels for any purpose up to twelve feet in diameter without the necessity of blocking or interfering with traffic in the case of street operations. On the present operation the machine has achieved a speed of about five feet per hour.

A Second Simplon Tunnel, parallel to the first, which is 12¼ miles long and the longest tunnel in the world, has been completely pierced, and the work inside is so far advanced that trains will use it by the end of January. The piercing of the second tunnel was not undertaken any too soon, for, owing to the tremendous overhead pressure, the roof of the original must be considerably reenforced. The tunnels join in the center, and on the Italian side the roof of the old tunnel must be repaired immediately.

Dr. K. G. Matheson, who has been president of Georgia Tech for twenty years, has resigned to become president of Drexel Institute in Philadelphia. Dr.

Matheson is one of the foremost educators of the South and has made a splendid record at Georgia Tech.

The American Electric Railway Association convention was held at Atlantic City, October 3-6. Delegates expressed the opinion that the transportation business of the electric lines is in better shape than a year ago. Herbert Hoover addressed the convention on "The Uses of Electric Railways in Improving Industrial Efficiency." The convention also considered the advisability of wide publicity for the purpose of interesting the public and securing its good will, and the problem of jitney bus competition, which is a serious factor with many lines. Roger W. Babson '98 delivered one of the principal addresses of the meeting.

$7,000,000 Electrifying Contract.—The Westinghouse Electric International Co. has received a $7,000,000 contract to supply the equipment for electrifying the Chilean State Railway between Valparaiso and Santiago and Los Andes. The road, which is now under steam operation, is 116 miles long and is the most important in Chile. The contract was obtained in competition with German and other European concerns. The equipment calls for eleven passenger, fifteen road, and seven switching locomotives, besides five complete sub-stations. The system is to be operated upon 3000 volt direct current and all equipment is to be strictly American standard.

The Bethlehem Steel Corporation has purchased the entire interest in the Baltimore Dry Dock and Shipbuilding Corporation. These additional facilities located in the main harbor of Baltimore, supplementing Bethlehem's Sparrows Point plant, will give Bethlehem a complete equipment of dry docks and marine railways to accommodate all kinds of ship repair work in the port of Baltimore.

Paper Mill for Siam.—Siam will soon have an experimental paper mill made in America with equipment recommended by the U. S. Bureau of Standards. The mill is complete in every detail and spare parts and supplies are included in the shipment. It is capable of producing about 1,200 pounds of paper daily which will be used chiefly by the Siamese army. The mill will be erected and operated in Bangkok under the supervision of an American paper maker and engineer. Siam is interested in paper-making because of the possibilities of turning some of her abundant grasses, weeds and fibrous plants into paper. The mill will be used in research in regard to the availability of rice, straw, banana tree stems, and lalang grass, all of which have shown possibilities of being used for paper making.

The Nippon Electric Company, an allied company of the International Western Electric Company of New York, said to be the oldest concern with participating foreign capital in Japan, has joined forces with the Sumitomo Wire and Cable Works of Osaka, also one of the oldest commercial enterprises in Japan. A new company has been organized, to be known as the Sumitomo Electric Wire and Cable Works, Limited, capitalized at about $5,000,000. Under the provisions of the alliance, the Nippon Electric Co. has granted to its new associate the right to use all of its manufacturing and engineering information and patents received from the Western Electric, covering the production of cables. The Sumitomo Co. has agreed to assist the Nippon Co. in the sale not only of electric wire and cable, but also of all its other products.

The Army Ordnance Association met October 7 at the Aberdeen Proving Grounds where many recent developments of the Army Ordnance Corps were demonstrated to them. A flashless gunpowder with which night firing of guns up to five inches with only a momentary dull glow and no illumination can be accomplished was a feature of the meeting. Salt and chloride of potash have been mixed with the powder to eliminate the flash. Other features included the firing of the heaviest single piece of ordnance in the world, the recently perfected sixteen inch 50-calibre gun mounted on a disappearing carriage. This gun measures sixty-nine feet in length, weighs 340,000 pounds, and requires 850 pounds of smokeless powder to propel its 2400 pound projectile twenty-two miles. A new and enlarged 50-calibre Browning rapid-fire gun using ammunition twice as large as that used heretofore was also shown. Races between self-propelled gun mounts wound up the daylight ceremonies; the night operations included besides the demonstration of the flashless powder, the firing of tracer ammunition at a free balloon.

A New Altitude Record of 40,800 feet was recently set by Lieut. John A. Macready, a test pilot at McCook Field, Dayton, Ohio. The plane used was the same le Père biplane in which Maj. Schroeder set the previous record on Feb. 28, 1920. The flight was made primarily for the purpose of testing improvements made on the supercharger invented by S. A. Moss '90 and also a propeller of very high pitch perfected by engineers at the field expressly for high altitude flying. Macready was in the air one hour and forty-seven minutes. At 39,000 feet ice formed on his oxygen tank but he pressed on until his altimeter registered 41,000 feet, when his engine stopped and he was obliged to glide to earth.

THE NEW 16 INCH, 50 CALIBER GUN

The Laws of Evaporation of the Great Lakes have been found after eleven years of research backed by the Carnegie Institute, said the Director of the School of Engineering of the Northwestern University, the other day. It is upon these laws that the questions of regulating lake levels, developing waterpower and draining great cities of their sewage depend.

A Semi-Mechanical Process for Sculpture with the aid of photography has been developed by Mr. H. M. Edmunds '05. The details of the process which is reported to be very complicated are not obtainable as we go to press. It is said to give remarkably fine results.

The Alabama Power Company is building an additional hydro-electric plant on the Coosa river near Verbena. Through an improvement in design the standing wave or hydraulic jump which has always reduced the capacity of such plants has been overcome, say reports. An investment of $9,000,000 is entailed by this project.

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TECHNOLOGY, SCHOOL FOR GRADUATES

In the report which the Registrar recently submitted to the Corporation, the registration of the Institute for this year was given as 3,335, the largest in the history of the Institute. This is a fine showing, but we are apt to overlook the fact that the Institute is undergoing other changes than one of mere growth. A study of the statistics on the registration of students from other colleges brings out some points which are worthy of our attention.

In 1914, for example, the number of graduate students at the Institute was 238, while the total number of students from other colleges raised the total to 18% of the Institute registration. This percentage increased evenly to about 25% in 1917, but in 1918, the year of the Army Training Corps, it dropped again to less than 10%. Since the war the percentage has increased until in 1920, the year just past, it reached 36%, while 15% attended the graduate school.

Just what do these statistics mean to the undergraduate? Without doubt, they show that the percentage of student graduates at the Institute is constantly increasing. This year's figures would seem to indicate a slight falling off. Definite statistics are not yet at hand. A report on the army officers who are taking up ordnance work is not yet completed; but even without this information it is certain that the proportion of students at Tech from other colleges is only slightly lower than last year. There are many reasons which could account for this slight droop in the curve for this year. Not the least important of these are the financial depression and the increased cost of the Institute courses.

But even if we take into consideration the slump in this year's curve, we can see by a comparison of statistics that, even under the present conditions, the proportion of students from other colleges is greater this year than it was under pre-war conditions. The number of students who come to the Institute directly from preparatory schools is constant. But this would not seem to us to be distinctly encouraging, for if over the last four years the number of students who come to Tech directly from preparatory schools is constant, the percentage of students entering Tech in this way must have fallen off fully 25%

The registration of students from other colleges, then, is constantly increasing. But what is more important, it is increasing faster than is the total registration of the Institute. They are in a constantly growing proportion. Without a doubt, these figures indicate a marked tendency in the Institute toward becoming a school for graduates. In spite of the financial depression of this year, we are farther advanced in that direction than we were in 1916 before the great increase which war conditions brought on. This is the situation. It seems not unlikely that before many years Tech will have become exclusively a graduate school.

LOOKING FORWARD

Power! What a variety of pictures that mystic word may conjure up in the mind of the technically-trained man! Before him may appear a coal mine, out of whose dark interior are daily drawn many tons of material in which the sun's energy has for countless ages been stored. The scene changes, and he sees that energy being liberated in the boiler of a giant locomotive, drawing its train of heavy Pullmans to the summit of a high mountain pass. Another vision appears, the trim and shining interior of a central power station, with its rows of automatically stoked boilers, reciprocating engines, or humming turbines, and dynamos, busily engaged in transforming the heat energy of the coal into electrical energy, for use in factories and homes at great distances from the source of supply.

But all these are visions of the past. If our imaginative engineer be inclined to look into the future, he will picture to himself a roaring mountain cataract, the force of whose fall is sufficient, when properly harnessed, to supply light and power to a surrounding area many thousands of square miles in extent. For truly, the age of steam power will soon be past. The cost of producing electricity from coal is increasing to heights which will soon be prohibitive; cheaper power must be had; and the answer is: hydro-electricity.

In the far West, this source of power has long been the principal one, although the quantity of such power available, but as yet undeveloped, is enormous. Water power is being developed more rapidly in California than in any other state at the present time, yet only one-fourth of that state's total supply of 4 million water horse power is now under control. However, competent authorities predict that, due to the rapidly increasing demand for such power, the development of the remainder will be complete within the next fifteen years. A mammoth project for damming the Colorado, the third largest river in the United States, is now under way, and the result will be of incalculable benefit to the entire Southwest, since it will mean the production of at least 3 million water horse power and the reclamation of an immense area of extremely fertile land, capable of supporting a population of 75 million people. And in the Northwest, also, where there is more water horse power available per square mile than in any other part of the country, similar projects, for the development of the Columbia River and other streams in Washington and Oregon, are receiving favorable consideration.

But it is in the industrial East, and not the agricultural West, that the greatest need for cheaper power is felt. A quarter of the country's population is concentrated in a region representing only 2 per cent of its total area, and as this region is the manufacturing center of the United States, it is natural that much interest should be manifested in the proposed "super-power system," which contemplates the construction of great power stations along the St. Lawrence River and in the mountainous regions of Pennsylvania and Virginia. These, together with further developments at Niagara, will supply the entire manufacturing area from Virginia to

the New England States with hydro-electric power, at an estimated saving of 24 per cent a year on the required original investment of a billion and a quarter dollars. Thus, it is asserted, the system would pay for itself in less than five years, and would be a great step in advance of present comparatively uneconomical methods of power production. A single advantage, aside from economic considerations, would be the abatement of the smoke nuisance in our large manufacturing cities, thus paving the way toward making ugly cities beautiful.

In short, the engineers' dream of hydraulically generated power for the whole country is no idle one, it is an assured reality, and complete electrification of all industry and transportation will soon follow. The much heralded "age of electricity" furnishes the key to the solution of our power problems of the future.

THE METRIC SYSTEM

The metric weights and measures constitute a scientific system; our system is a disorganization. It is now generally admitted by the majority of intelligent persons in this country that the metric system is a much simpler and better system than that based on the customary Anglo-American standards. The metric system is an international system in the sense that it is employed in all accurate scientific work, in America as elsewhere, and also that it is in use in everyday life in all civilized countries excepting America, Great Britain and its colonies.

The first step should be to bring commercial organizations of this country to a realization of the fact that our present system of standards is injurious to our foreign trade. The importance of the use of the metric system not only in foreign commerce but also at home is becoming recognized. It is necessary to us because a large part of the world with which we carry on commerce has adopted it. Commercial organizations must be brought to realize that the present system is very wasteful of our most precious commodity—time. The saving of time brought on by the use of the metric system would repay the annoyance brought on by the change.

We have observed the fact that a change to the metric system is needed for the sake of foreign commerce. We are encouraged by the fact that several large chemical concerns are now using this system as a business basis. In addition we now see that we need it also in general commercial and manufacturing transactions. If we are to have the efficiency so insistently demanded by the age in which we live, then we must have the metric system in use for the ordinary affairs of daily life of the mass of the people, we must have it in education, and we must have it in commercial and manufacturing industries. If efficiency is to be the slogan of this country, then the metric system must come, no matter what obstacles stand in its way.

PLAYING THE GAME

The most contemptible specimen of humanity is a man who will cheat at solitaire. There is no lower. Each new year of Institute life finds us faced again with the problem of honesty in our work. Some of us look ahead at the prospect of the year's work and settling to the grind determine to make the best of it, to get what we can. Others take a different attitude; they stack the cards.

Now if a student in a classical college adopts this attitude toward his course, he is doing himself a great injury. He is tearing down his moral stamina; each time he uses dishonest means in the performance of his academic duties he is making it just so much easier to repeat the action. Each time he deliberately deceives himself by letting another do his work, he is making it just so much easier to deal with fraudulent ideas, he is undermining his own ability to think clearly and to deal with true conceptions. He is committing mental suicide.

Cheating for the student engineer, however, is not only suicide but murder. If there is one man upon whom society depends for absolute integrity, that man is the engineer. Let the engineer be dishonest in his thinking and his buildings collapse, his bridges fall into the river, his engines go to pieces, his dyes fade. Honesty with the engineer is not a personal affair; it is a matter of vital social importance.

For these reasons it is essential that the student engineer develop habits of honesty. But there are other considerations which should compel him to follow the straight and narrow, from which there can be no turning. Every man who comes to the Institute is here for a purpose. He is here to equip himself to serve society in a particular way. He is here for the purpose of getting a specialized education. There is only one way in which he can do this, that is by playing the game fairly. The other method may often appear easier; the path of the crook may at times seem smoother, but in the long run it must fail, for it leads to the wrong goal. Honesty is the only possible policy for the real engineer.

ARE YOU A THINKER?

We are convinced that a general discussion is needed of the questions raised in the editorial of the last issue on "The Technology Theory of a Technical Education." As students we ought to study the process which is going, or ought to be going on, in our own minds. The test-tube or the dynamo or the steam cylinder contain no mysteries of which we should have a better understanding.

It stands to reason that there must be principles and plans by which this construction, known as education, takes place. But what are they? Most of us, if not, indeed, all of us, feel that Technology has found a tremendously effective educational system for engineers. But as to what the distinctive features are, we venture to say that opinion would show great variation. If there is a clearly stated working educational hypohtesis, upon which the Institute's courses are based, we do not know it.

But there ought to be. And individually, every student ought to think out such questions as these: What is a liberal education? Is a Tech education of itself a liberal education? If not, what is needed in order to make it a liberal education? Should an engineer have a liberal education, anyway?

Of the educational writers, the greatest are probably John Henry Newman, Matthew Arnold, Thomas Huxley. Even they can do little more than furnish a background for one's own thought.

Suffice it to say that the student, as the most active agent in his own education, should stand in a position to direct it and correct it and, as a Tech man, should know why Technology is the great engineering school.

RECOMMENDED ARTICLES

"General Welding Practice," Acetylene Journal, October, 1921.

"Behind the Exhibits," (Preparation of Museum Exhibits) Scientific American, October 8, 1921.

"Wilson Dam and Muscle Shoals," Cement and Engineering News, September, 1921.

"The Zeppelin-Staaken 1000 H. P. Monoplane," Aviation, October 3, 1921.

"White Star Liner *Majestic*," Marine Engineering, October, 1921.

"Building the Joliet-Morris Road in Illinois," The Excavating Engineer, September, 1921.

"Wonders of Directional Wireless," Current Opinion, October, 1921.

"The Rising Importance of the Oil Injection Type of Internal Combustion Engine," Mechanical Engineering, October, 1921.

"Standardization and Aerodynamics," Aerial Age Weekly, October 3, 1921.

"A New Nlseco Diesel Engine," and "Loaded Sea Trials of the Motorship *William Penn*," Motorship, October, 1921.

THE CONVENTION OF THE NATIONAL SAFETY COUNCIL

Special Correspondent of The Tech Engineering News at the Convention

Over a thousand men from all parts of the country assembled at the State House in Boston during the week beginning September 26 for what was probably the most enthusiastic gathering ever held for the purpose of preventing the thousands of accidents which occur yearly in industrial and private life, and for considering the practical engineering methods which will help prevent many of these accidents. For the entire week the corridors and assembly rooms of the State House were filled with men and women engaged in discussing various safety appliances, and ways of improving upon operations which are classed as dangerous. Every one of the various section meetings had speakers who had definite topics to discuss, and in several of the meetings there were interesting exhibits showing just how some accidents occur and how they may be prevented.

On Monday, September 26, the annual meeting of members was held. Reports for the past year were read, and resolutions were adopted calling upon manufacturers and engineers to provide specified safeguards for dangerous machines, to redesign and reconstruct factory equipment in order to remove industrial hazards, and to aid in the education of all persons in regard to safety precautions. After the general meeting, the various section meetings were held.

In the Automotive Section, David J. Price of the U. S. Department of Agriculture read a paper on "Dust Explosions —their Nature, Causes, and Methods of Prevention." An assistant demonstrated with a model how grain explosions occur. The model consisted of a small tin box made to represent a grain elevator, a pair of bellows, a small amount of corn starch, and a can of Sterno. The "elevator" had a paper diaphragm in the top to relieve the pressure generated by the explosion. To produce the explosion, the can of Sterno was lighted and placed inside the elevator. A small amount of corn starch was blown in by means of the bellows and immediately, with a loud report, the diaphragm was broken and a flame leaped at least 15 feet in the air.

Mr. Price in his paper said, "Dust explosions are similar in nature to gas explosions. All that is required is the ignition of a certain amount of dust and air mixed in proper proportions, just the same as explosive gas mixtures. The degree of fineness of the dust particles is a prominent factor, and the finer the dust particles, the more violent the explosion. The most destructive dust explosion on record occurred at South Chicago on March 21, 1921, in a large 10 million bushel grain elevator. The explosion caused the destruction of more than four million dollars worth of property and the loss of six lives . . . . the mortality is very high in dust explosions since all persons in the affected zone have been either killed or seriously injured. It is therefore essential that the explosive dust hazard be fully recognized and precautionary measures taken." . . .

Another interesting paper in the Automotive Section was read by W. J. Pefferley of the Square D Company. He is quoted as saying, "Why is electricity, when not properly installed and safeguarded, a more dangerous hazard than a mechanical one?—The eye and the brain work in harmony. The instant the eye observes an object in motion, such as a gear, or belt, the brain impels the feeling of fear and precaution. With electricity, that invisible force, there is no motion; the distribution installation and control apparatus look harmless." He went on to say that the greatest hazard in the factory is low tension distribution. For, although it is true, as often stated, that voltages lower than 600 can be taken across the fingers harmlessly, if one happens to be grounded, death may result. Furthermore, a person accidentally coming in contact with a live wire is likely to be killed even at low voltages because his nervous system is not set to receive the shock.

In the Engineering Section, whose meetings were held at M. I. T., two of Technology's Alumni spoke, J. I. Banash '06 on "Lessons learned from Oxy-acetylene and other Gas-Welding and Cutting Processes" and Dr. W. K. Lewis '05 on "Safety in the Evaporation of Volatile Solvents." Both of these papers were excellent and showed that Technology men are by no means behind the times in safety work.

The chief emphasis of Mr. Banash's speech was that many accidents attributed to oxy-acetylene processes and equipment have been due to causes entirely foreign to the oxy-acetylene industry. As Mr. Banash says, "the average reporter seems to have an especial weakness for the word *oxyacetylene* as if it were a term that could be generally applied to a proper denomination of all mysterious, or not definitely accounted for explosions and fires." The total value of last year's loss attributed to acetylene was only $16,800 of which 70% is attributed to gross carelessness.

When one enumerates the number of instances in which the oxy-acetylene industry has played life-saving parts such as the saving of a great number of lives in the capsizing of the Steamer Eastland, and counts up the number of instances when the oxy-acetylene blow-pipe has saved the lives of persons imprisoned in safes, we can most certainly say that the oxy-acetylene industry plays a most important part in safety work. Acetylene plays a tremendous life-saving part in the manner of marine safeguards such as light-ships, light-houses, and beacons.

Dr. Lewis gave a report on what safeguards can be applied in the evaporation of volatile solvents such as used in the manufacture of rubber cements, dopes for airplane wings, artificial leather coatings, lacquers, varnishes and enamels.

The Public Utilities Section was concerned with safety measures as they are applied to gas plants, electric light companies, electric traction companies, et caetera. In dealing with the risks incurred in handling and storing coal and oil, there was an interesting paper read by C. E. Paige of the Worcester Gas Light Company. Under the heading of coal fires he said, in part, "The great difficulty comes with coals that do not appear dangerous until the fire actually starts. Anthracite coal gives no trouble in storage and gas coal of reasonable quality rarely gets afire. The great risks are in bituminous and semi-bituminous coals of poorer quality. . . . It is well for many reasons to take precautions in all cases where there is the slightest question as to the origin or quality of the coal.

"Fire risk may be reduced if precautionary facilities are provided and used. There is no danger of spontaneous combustion if suspected coal is stored under water. Such storage is not often practicable. . . . Coal is not likely to fire if stored under cover of a shed with air-tight sides and a good flooring. The risk is reduced if coal can be unloaded without breakage, which often exposes new surfaces for heating."

The Mining Section discussed the various laws which require regulations governing the number of openings in a mine, the size of shafts and drifts, and also stairways and ladderways. Most states now require all travelled ways in mines to be designated by signs. This is required so that men may not become lost in trying to find their way out of a mine in case of fire or other emergency.

Under the Council's auspices, First Aid work has been carried on with extremely good results. In almost every industry, First Aid lectures and safety instruction have been instituted and First Aid contests have been held. It is of great importance to remember that in almost every case where safety regulations are carried out, there is a resultant increase in both production and efficiency of the industrial plant.

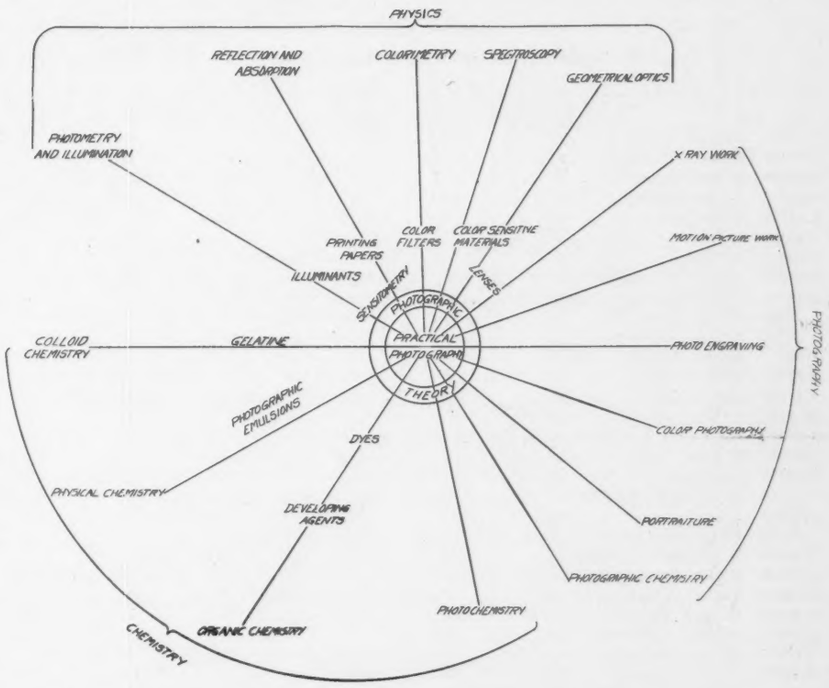
THE WORK OF A PHOTOGRAPHIC RESEARCH LABORATORY

(Continued from Page 109)

work in the laboratory has been the study of the photographic developers in relation to their behavior in the development of the latent image, and the relation of the constitution of the many compounds possible to their properties is being attacked in the laboratory by the collaboration of the department of organic chemistry, which prepares the compounds in question, and of a special laboratory which deals with the physical chemistry of developers. In this laboratory the developers are examined both by their action upon the photographic emulsion and also by the recognized methods of physical chemistry. The most fundamental property of a developing agent is its reduction potential, and this should apparently be measurable electrically by comparing the electromotive force produced on a platinized cathode immersed in the developing agent with the potential of an electrode charged with gaseous hydrogen.

The rate of development is dependent on two factors: first, on the rate of the chemical reaction itself; that is, on the solution of silver bromide, its conversion into metallic silver, and the precipitation of the metallic silver in a solid form; and secondly, on the rate of diffusion of the developer to the silver bromide grain and of the products of development away from the grain. The second of these factors has by far the greater influence in settling the rate of development, though the time of first appearance of the image appears to be dependent chiefly upon the rate at which the developer attacks the silver bromide grain. It is in the rate of attack on the silver bromide grain that the reduction potential plays so great a part, but this rate of attack under ordinary conditions is limited by the rate of solution of the silver bromide, and a developer does not attack the silver bromide grain proportionally faster by reason of an increased reduction potential.

The reduction potential of a developer, in fact, may be compared to the horse power of an automobile, which for other reasons than the power of its engine is limited in speed. If we have two automobiles and they are confined to a maximum speed of twenty miles an hour, then on flat roads the one with the more powerful engine may be no faster than the weaker, but in a high wind or on a more hilly road the more powerful engine will allow the automobile to keep its speed, while with a weaker engine the speed would fall off; we can, indeed, measure the horsepower of an automobile by the maximum grade which it can climb at a uniform speed. In development the analogy to the hill is the addition of bromide to the developer, since the addition of bromide, by the lowering of the solubility of the silver bromide, greatly delays the chemical reaction in development, and the higher the reduction potential of a developer, the more bromide is required to produce a given lowering of the density, so that we can measure the reduction potential by the amount of bromide required to produce a given effect. If we measure the common developers in this way, we shall find that glycin has the lowest reduction potential, then hydroquinone, then pyro and paraminophenol, and finally diamidophenol has the highest.



GRAPHICAL REPRESENTATION OF THE FIELDS COVERED BY THE RESEARCH LABORATORY

Reproduction of Tone Values

In photography the object is to produce in the observer the same impression of the relative brightness of the scene reproduced in the print as was produced at the time that the photograph was taken. It is clear that a study of this can be divided into two sections, one dealing with the objective reproduction in the print of the scale of light intensity which occurred in the original subject, and the other concerned with the subjective impression produced on the observer both at the time of viewing the subject and later when viewing the print. With regard to the objective side of the subject, let us consider first of all the way in which a scale of brightness is reproduced in the photographic process from the original subject through the negative to the print.

There are four separate sections involved in this investigation: first, the study of the range of brightnesses occurring in natural objects such as one is required to photograph; second, the study of the way in which the photographic emulsion translates a scale of light intensities into deposits of metallic silver in the negative; third, the study of the properties of photographic printing papers and the relation of the reflecting power of the deposits obtained in them to the scale of light intensities to which they were exposed; and fourth, the study of the accuracy with which the tone values of the original are rendered through the negative on to the printing paper.

Until recently the scale of rendering of a negative material was all that had been fully investigated. This was done by Hurter and Driffield as has already been mentioned. They studied the relation between the exposure of the photographic material and the blackening produced, but in order to render possible the study of the reproduction occurring in photography an investigation of the sensitometry of papers was also necessary.

In the first place, an instrument was designed by means of which the light reflected from small areas of the exposed print could be measured. Papers were then exposed for known periods of time, developed, the reflecting power of the developed image measured and curves plotted of the logarithm of the reciprocal of

(Continued on Page 128)

A SHORT METHOD OF IDENTIFYING ORGANIC COMPOUNDS

By WALLER V. MORGAN, '22

Waller V. Morgan '22 has developed a short method for the analysis of pure organic liquids by using the refractive index and the boiling point of the liquid for identification. Morgan's method, besides being very short, offers the added advantage of leaving the sample practically intact. The only laboratory work necessary is a determination of the boiling point and another of the refractive index. Morgan has prepared a table of 128 of the most common organic liquids, arranged according to the index of refraction, and giving also the boiling points. Once the index and boiling point are known it is a matter of a few moments to locate the substance in the table. If a check is desired, the specific gravity, smell, color, taste, etc., will suffice. In determining the index of refraction it is necessary that the liquid be pure and at a known temperature, but these conditions are easily complied with since the distillate obtained from the boiling point determination is sufficiently pure. Morgan's method has been approved by Institute professors, but the method will not be used in the undergraduate laboratories because of the small amount of chemistry involved. Morgan's table is as follows:

TABLE OF REFRACTIVE INDICES WITH BOILING POINTS

N—Index of Refraction at Temperature T. B P—Boiling Point of Liquid. *Melting Point.

N.		T.	B.P.
1.30099	Methyl Acetate	20	57.5
1.32945	Methyl Alcohol	20	66
1.33157	Ethyl Aldehyde	20	
1.3316	Acetaldehyde	20	20.8
1.35293	Ether (diethyl)	20	35
1.3581	Pentane	15.7	37
1.35915	Acetone	20	56.5
1.35985	Ethyl Formate	20	54.4
1.36	Ether (diethyl)	20-22	35
1.36138	Ethyl Alcohol	20	78.4
1.36356	Propyl aldehyde	20	48.8
1.37	Ethyl Alcohol	20-22	78
1.3714	Formic Acid	20	100.8
1.37182	Acetic Acid	20	118.1
1.37257	Ethyl Acetate	20	77
1.37302	Iso Butyl Aldehyde	20	63-64
1.37536	Hexane (n)	20	69
1.37576	Amylene	20	39-40
1.37757	Iso Propyl Alcohol	20	82.8
1.38193	Acetal	20	104
1.38433	Butyl Aldehyde	20	73-74
1.38438	N. Propyl Acetate	20	102
1.38523	Ethyl Carbonate	20	126
1.3853	Ethyl Nitrate	20	87.6
1.38543	Propyl Alcohol	20	97.4
1.38856	Propyl Chloride	20	46.5
1.38891	Methyl Butyrate	20	102.3
1.38976	Acetyl Chloride	20	55
1.39	Heptane	20-22	98
1.39038	Acetic Anhydride	20	137
1.3945	Hexylene N	23.3	68-70
1.39479	Methyl Valeriate	20	127.3
1.39594	Iso Butyl Alcohol	20	106.5
1.39599	Ethyl Butyrate	20	119.9
1.39667	Butyric Acid	20	162.5
1.39704	Ethyl Valeriate	20	144.5
1.39799	Amyl Formate	20	130.4
1.39909	Butyl Alcohol	20	117
1.39975	Acrolein	20	52.4
1.40	Amyl Alcohol	20-22	132
1.40032	Tri Ethyl Amine	20	89
1.4007	Octane N	15.1	125.5
1.40376	Amyl Acetate	20	148
1.40448	Allyl Acetate	20	103-104
1.40507	Propylene Chloride	20	96.8
1.40783	Amyl Alcohol	20	137.8
1.41043	Ethyl Oxalate	20	186.1
1.4108	Decane N	14.9	173
1.41194	Amyl Valerate	20	194
1.41209	Butyl Chloride	20	77.5
1.41345	Allyl Alcohol	20	96.6
1.41538	Allyl Chloride	20	44.6-46
1.41976	Ethyl Acetoacetate	20	181
1.42406	Ethyl Bromide	20	39
1.42508	Propyl Bromide	20	71.5
1.42743	Ethylene Glycol	20	197
1.44118	Amyl Bromide	20	128.7
1.44432	Ethylene Chloride	20	84
1.44621	Chloroform	20	61.2
1.45068	Trichlor Ethyl Acetate	20	197
1.45303	Palmitic Acid	20	dec
1.45468	Stearic Acid	20	291 (100 mm)
1.45572	Chloral Ethylique	20	
1.4557	Chloral	20	98
1.45963	Oleic Acid	20	286 (100 mm)
1.46	Carbon Tetrachloride	20-22	76
1.4607	Carbon Tetrachloride		76
1.46	Cajeput Oil	20-22	174
1.47	Glycerine	20-22	290
1.47	Turpentine	20-22	155
1.47	Olive Oil	20-22	
1.47293	Glycerine	20	290
1.47554	Chloral Butylique	20	
1.48	Castor Oil	20-22	
1.49	Xylene	20-22	136
1.49	Benzene	20-22	80
1.49116	Mesitylene	20	164.5
1.49542	Ethyl Hydrocinnimate	20	247-249
1.49552	Toluene	20	111
1.49597	Iso Butyl Iodide	20	120
1.49969	Iso Propyl Iodide	20	89.5
1.50	Clove Oil	20-22	
1.50006	Butyl Iodide	20	129.6
1.50144	Benzene	20	80.36
1.50508	Propyl Iodide	20	102.4
1.50602	Ethyl Benzoate	20	212
1.51	Cedar Wood Oil	20-22	
1.51307	Ethyl Iodide	20	72.3
1.51692	Methyl Benzoate	20	199
1.52	Mono Chlorobenzene	20-22	132
1.5239	Nicotine	22.4	247.3
1.52479	Mono Chlorobenzene	20	132
1.52565	Phenyl Propyl Alcohol	20	235
1.52973	Methyl Iodide	20	42.5
1.53806	Ethylene Bromide	20	131
1.53953	Benzyl Alcohol	20	204.7
1.5425	Phenol	40.6	42.5
1.54638	Benzaldehyde	20	179.5
1.5485	Styrene (Vinyl benzene)	16.6	144
1.55291	Nitrobenzene	20	210
1.55503	Phenol	20	*42.5 183
1.55977	Mono Brombenzene	20	155
1.5632	Methyl Aniline	25	195.5
1.5725	Anisol		155

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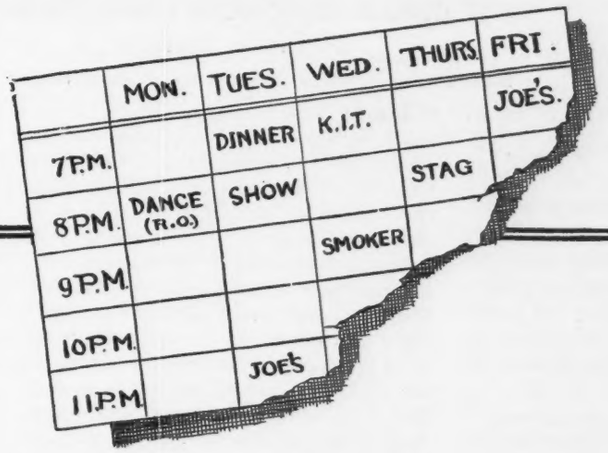

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"The heights by great men reached and kept
Were not attained by sudden flight,
But they while their companions slept
Were toiling upward in the night."

But if you intend to make your mark in engineering or business, don't expect that supremacy on the waxed floor will help when you start hunting a job.

Not that you need swing to the other extreme as a "grind" or a hermit. Let's concede it is all right to minor in sociabilities—but certainly it is only common sense to major in the math and sciences and English that will mean bread and butter to you later on.

Remember this—the harder you work right now in getting a grip on fundamentals, the easier things will come to you when you must solve still bigger problems. And if you take it easy now—well, look out for the law of compensation.

It's up to you. While you've got the chance, seize it, dig in, plug hard. It will pay—in cold cash.

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Maybe it's against all campus tradition, but some men who stood in the upper third in their class and who entered this Company years ago have since become its executives.

NORMAL BUSINESS CONDITIONS

By FRANK V. BURTON

Sales Manager, Weber Electric Co., Schenectady, N. Y.

In giving a review of business conditions as seen from the viewpoint of one having in charge the sale of the output of a factory making electrical wiring devices, I am impressed with the fact that, in one respect, at least, the electrical supply business is similar to almost every other business in that the conditions are very difficult to analyze. The few businesses that are not difficult to analyze are mostly those of the man who failed to lay by an adequate part of the profits that resulted from the orgy of business in the post-war days and now has nothing to go on when profits are small or, as is frequently the case, "a. w. o. l." That man is broke and it is simple to find the reason.

We hear a great deal these days about "normal" conditions and our President has given currency to the hitherto obscure word "normalcy." What are normal conditions? Are conditions ever normal? There are some businesses that have their greatest activity when the majority of businesses are depressed. For instance, I have a friend who manufactures paper bags, and his sales are largest in dull times. The explanation seems to be that, when the wage earner is short of money, he buys his provisions in small quantities, resulting in a greater number of sales for the same aggregate of business and a consequent increase in the number of paper bags used. When is this man's business normal, would you say?

I have an idea that the arrival of the prosperity we all so much desire is delayed because we expect that normal conditions will begin on a certain day, much like Thanksgiving Day and with much the same formality. We expect to pick up the paper some morning and read a proclamation by His Excellency, the President of these United States, to the effect that he appoints Friday, October thirteenth, as Normalcy Day, invites all merchants to put their prices at the 1914 level and all buyers to buy as they did "before the war." There will be a grand parade with bands playing and colors flying. Next morning we shall all go to our respective places of business and find that sales are large, profits adequate, and from then on, every one will be happy.

I do not acquiesce in that view of the matter at all. My theory is that normalcy is an individual matter. A's business felt the depression six months before B's did. Perhaps B jollied himself into believing that "his business was different" and there would not be any slump. But one day it arrived most unmistakably, and perhaps about that time A's business began to improve. In other words, every business is subject to so many cross-currents that the man who keeps pulling at the oars will be farthest along when the tide turns and he is once more in the happy situation of going with the current. It may be some gratification to theoretical minds to have Mr. Babson present a curve showing that *average conditions* are still tending downward and that the bottom will probably be reached in November. But the man who succeeds is the one who is thoroughly informed as to the influences that affect his individual circumstances and lays his plans accordingly.

For example, the electrical supply business always reaches its greatest activity in the Fall of the year. It not infrequently happens that the business done in the last four months equals that of the first eight months. Why is this? The answer is not difficult to find. Buildings that were started in the Spring have advanced to the point where they are ready for their electrical equipment. Also, the days are growing shorter, and existing electrical installations are being repaired and extended. These conditions will always exist, and this year, as in previous years, they are operating with noticeable effect. True, the buying is not equal to that of 1919 and 1920, for the amount of new building construction done this Summer was pitifully small. But the improvement is sufficient to result in an increased number of employees in our factory. That result, repeated many times in other electrical supply factories, electrical jobbing houses, etc., and duplicated hundreds of times in other lines of business, means that the wage earner will have some money to spend, and that, in the last analysis, is the basis of our prosperity.

So let us cease this prating about "normalcy" and each of us devote his energies to solving the problem that is on his own doorstep. Only so will prosperity arrive.

STAINED AND PAINTED GLASS

(*Continued from Page 107*)

of the effect of light and optics; manners perfectly understood and employed by the glass painters of the twelfth and thirteenth centuries, neglected from the fifteenth century on, and afterwards distained, in spite, as we have said, of the immutable laws imposed by light and optics. To try and reproduce what is called a picture, that is to say, a painting in which one seeks to render the effects of linear and aerial perspective, of light and shade with all their transitions, on a panel of transparent colors, is an undertaking as daring as to attempt to render the effect of the human voice with stringed instruments. Different processes, different conditions, different branches of art. In an opaque painting, in a picture, the radiation of the colors is absolutely under the control of the painters, who, by halftones, shadows of diverse intensity and values, according to the different planes, can diminish or augment it at will. The radiation of transparent colors in glass cannot be thus modified by the artist; whose whole talent consists in profiting by it to work out a harmonic scheme on a single plane, like a rug, not in working out effects of aerial perspective."

The sincerity and good taste of many present day architects have done much to restore respect for this decorative art so closely related to architecture. Their influences are to be felt in a renewed, intelligent interest in great achievements of the past, and in a growing demand for work by inspired artists and craftsmen today. This is, of course, as it should be, for the first consideration of the maker of windows should have to do with the building which is to contain them. The problem of church lighting, while it reveals fascinating possibilities, offers sobering responsibilities which architect and "glassman" must share.

In no other decorative medium are successes more gratifying in their power to enhance the distinctive character and beauty of an interior, nor are any other failures so fatal to the efforts of the architect, and of all who may have striven with him, to glorify and enrich the inner fabric of a church edifice.

It is generally felt that windows are designed to admit light and that whether they face the splendor of our mid-day sun, or have a less intense north light, the principle remains the same. The consideration of pictorial possibilities is no longer allowed entirely to displace the artist's allegiance to this principle. There is little question but that transparent colored or white glass (painted, so that the light is "stopped down" but not obscured in heavy masses) is the logical medium to use in the making of stained and painted glass windows.

One of the most interesting chapters

in the history of painted glass has to do with the reaction, evidently late in the thirteenth century, to mark the protest against dark interiors which were inevitable when windows in full color were used throughout a church edifice.

The manner in which the response was made to the demand for more light again awakens our admiration for the craftsmen of that period. Although, a type of grisaille, entirely in white glasses, leaded in small pieces with little or no paint, was known early in the twelfth century, it remained for the artist of a later period to add bands and spots of pure color, so that it took its place logically in edifices containing important windows in full color, and was often used effectively as a coherent part of windows containing colored medallions and figures.

One great secret of the beauty and effectiveness of grisaille is, of course, the strict adherence of its designers to the same principles of light and optics that marked their wonderful successes in the use of color.

On the field of varying tones of whites, the light is broken by flowing lines and by delicate lattices or hatchings, and the flashes of color, especially the reds and blues, are left practically clear of paint.

It is a curious fact that this truly beautiful type of painted glass was, until recently, represented in America by crude examples done mechanically, and entirely lacking in the silvery lustre and charming bursts of color which distinguish the old world grisaille. Today many American churches are enriched by grisaille, wrought sympathetically in the exquisite textures consistent with its highest possibilities, and painted with due regard for varying intensities of light.

Its cost is so moderate that, in many instances, a type of it is used for temporary glass, and thus the violent glare, so distasteful to architect and congregation, is most pleasantly avoided.

It is not within the range of this article, if indeed it be possible in any form of expression, to define the enduring beauty and charm of a worthy achievement in stained and painted glass. As well attempt to

"Write in a book the morning's prime
Or match with words a tender sky."

Its great, if not its greatest, distinction lies in color; and certainly no rules thus far formulated have furnished the subtle guiding influences which would produce, through cool intellectual processes, the glow and thrill of a true color composition.

It is essential to revert to early schools of window-making, not to copy drawing or composition (although a knowledge of both is necessary), but to realize their acceptance of the broad principles on which the craft is founded.

It is the lofty spirit that inspired the artists of old, vivid and vital in its inspiration, that we would reveal to all who are interested in the craft today.

Architects who are sincerely striving to build and enrich enduring structures will find this spirit struggling for expression, and at times bursting forth radiantly through the many discouraging conditions so evident now.

It is sure to prevail, eventually, among us as it has always prevailed among lovers of beauty throughout the centuries.

The Winnipeg Power Development.—More details concerning the Winnipeg River Power Plant, under construction at Great Falls, have come to our attention. The plant will be built in six sections of 28,000 H. P. each; and the dam when complete will be 70 feet high, 3,000 feet long, and will create a reservoir covering 1,935 acres. The work will require 1,000 to 2,500 men, and will probably be completed in 1924.

Most of us agreed with Bud Taylor, leader of Urbain Ledoux's unemployed cohorts from New York, who said to the latter in Washington, "It isn't doing us any good to pose before the camera. What we want is work."

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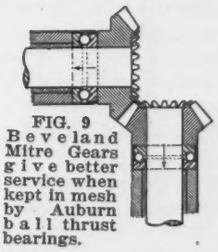
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THE WORK OF A PHOTOGRAPHIC RESEARCH LABORATORY

(*Continued from Page 123*)

the reflecting power against the logarithm of the exposure. Several constants were found to express the behavior of photographic papers; thus, any paper had a maximum density, that is a minimum reflecting power representing the deepest black which could be obtained upon it. It showed also a typical scale or total range of exposures through which any differences could be obtained with an alteration of exposure. Again, the straight line portion of the curve showed a definite steepness or "gamma," as we call it, and finally the length of the straight line portion is of great importance, since it is only throughout this straight line portion that exact reproduction can be obtained.

The method of obtaining the sensitometric characteristics of a positive material having been developed so that the results obtained were satisfactory, it remained only to combine this information with that relative to the characteristics of the negative material in order to obtain a solution of the objective phase of the tone reproduction problem. A graphic method was therefore developed by means of which this desired result could be accomplished. By use of this method it becomes possible to compute from the known or easily measurable factors, such as the brightnesses of the object, the constants of the image forming system, the illumination used in making the positive, and the intensity of illumination incident upon the positive during observation, the brightness values in the positive by which the various areas of the object are reproduced. By comparing these brightness values with those of the object, a quantitative expression of the quality of objective reproduction obtained can be formulated. This solution of the objective phase, however, is not all that is desired, for as previously stated the object in most cases of photographic work is the reproduction of the group of sensations resulting from an observation of the object.

In order to obtain the data necessary for this solution, a large amount of work has been done on visual sensitometry which deals with the determination of the various sensibility functions of the human eye. The data of particular importance in this case are those relative to the various brightness sensibility functions, especially that relative to contrast sensibility. These data having been obtained, the graphic solution was extended so as to include also the subjective phase and by the method as finally worked out it is possible to obtain a graphic representation of the quality of subjective reproduction. This is expressed by evaluating the characteristics of the subjective reproduction in terms of the subjective object and expressing this evaluation as a function of the brightness in the original object.

Many interesting conclusions, some of considerable practical importance, have been drawn as a result of the work on this tone reproduction problem. Among these may be mentioned the relation which should exist between the negative and the positive material upon which it is to be printed which may be stated by saying that the density scale in the negative should be equivalent to the exposure scale of the positive material on which the print is to be made. Another point of considerable interest and relating particularly to the subjective phase of the subject is that an enhancement or increase of objective contrast in the print may frequently be necessary in order to reproduce apparent contrast in the object, this being due to the fact that the contrast sensibility of the retina may be relatively low when viewing a print under a low illumination, while on the other hand the contrast sensibility is high when the observer views a brilliantly illuminated object.

Practical Photography

Naturally, a great portion of the work of the laboratory is concerned with photographic processes and work on all kinds of photographic processes is continually in progress. It is difficult to summarize this work in any brief form, but the work which is being done on color photography is perhaps especially worthy of note.

There are two main divisions of the practical processes of color photography; the processes which are known as "additive," in which the colors are produced by the superposition upon a projection screen or in the eye of beams of the primary colors, and the "subtractive" processes in which negatives taken through the primary filters are printed in colors complementary to those filters and these prints are then superposed.

Most of the work of the laboratory has dealt with the subtractive processes, though a good deal of research work has been done upon the filters required for the additive processes and upon such subjects as the color of mixtures of two nearly complementary colors, work which is of considerable interest in connection with the two color additive processes.

In work on the subtractive process of color photography some interesting results have been achieved in the photomicography of stained sections, a two-color process having been developed which gives very good results for this purpose. The two-color subtractive process of color photography has also been applied to motion picture work, the pictures being made by using a film coated on both sides with a sensitive emulsion, so that negatives taken through the red and green filters can be impressed in register on opposite sides of this double-coated film and then the double image after development can be transformed into dye images complementary in color to the filters through which the negatives were taken. In this way each picture on the film consists of two pictures of complementary colors which give the effect of a two-color subtractive picture. This process, of course, has the great advantage that film so made is suitable for projection in any ordinary motion-picture machine.

Owing to the intimate relation of photography to physics and chemistry, a great deal of work has been done in the laboratory in these sciences, thus in applied optics a number of studies have dealt with the reflection and transmission of light by diffuse media and with brightness measurements, the laboratory being especially well equipped to study absorption photometry both with and without the consideration of color. The study of color itself occupies a large part of the activities of the physics department, measurements have been made on the sensibility of the eye to color, to change of hue, and a number of investigations have been made on the use of the monochromatic and other colorimeters for the quantitative expression of color. In physical chemistry studies have been made on the physical-chemistry of gelatine and other allied colloids, and a monograph on gelatine is now in preparation. Methods of measuring viscosity, turbidity, swelling, and other physico-analysis constants have been developed in this department. In electro-chemistry also a great deal of work has been done. New methods for the electro-chemistry of silver solutions have been worked out, apparatus for the determination of hydrogen potential has been designed, and methods for the precise determination of conductivity have been developed.

A special department of the laboratory deals with the production of synthetic organic chemicals, its purpose being to supply the lack of those materials, so essential for the research worker in organic chemistry and which we formerly obtained from Germany. A price list containing about 1100 organic chemicals has been issued and this department of the laboratory is becoming a full fledged manufacturing department, supplying synthetic organic chemicals to the universities and the laboratories of the United States.

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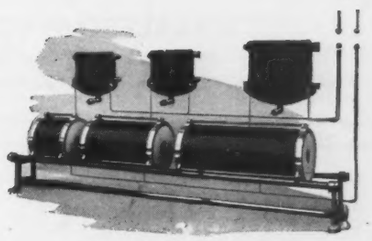

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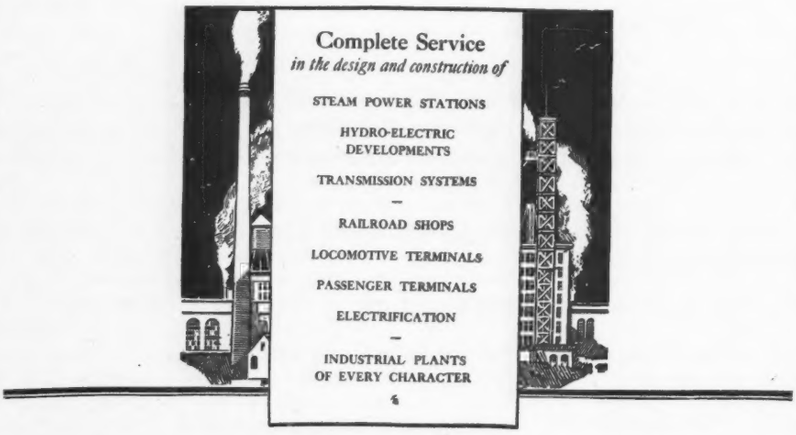

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OPPORTUNITIES FOR AMERICAN ENGINEERS IN FOREIGN COUNTRIES

In looking over the foreign field as far as it concerns American engineers, we naturally turn first to South America, Mexico and Central America. American engineers have done work in all of them and, on the whole, their people like us. All three of these countries need outside help for their developments, just as we needed it in the past. Besides money, however, they need our technical skill and our organizing ability. The field there, in almost every line of engineering endeavor, is limited only by the amount of money the American public is willing to invest.

Europe as a whole is able to take care of herself, with the exceptions of Spain, the Balkans, and Russia. The two latter countries need stable governments in advance of engineering improvements. Before the revolution in Russia, American engineers were investigating some important transportation, coal mining development, and steel manufacturing projects there, but for the present no advances can be made. On the contrary, Spain presents a very attractive field. With the exception of the Balkans, her material development is probably the most backward of any of the European countries. Here are to be found a good laboring population and large undeveloped natural resources.

In Asia the great fields are Siberia and China. Siberia, the future of which is linked with that of Russia, will open a great field for American enterprise, particularly in connection with the construction of railways and the development of its mineral resources. As in China, competition with the Japanese must be expected, but in this the question of investments will be the deciding factor. China is in many ways a most interesting country to Americans. It has a population of 330 to 340 millions of people, only about 7000 miles of railways, an area 50 per cent larger than that of the United States, and hardly any organized industries except, perhaps, in the production of tea and silk. It is just beginning to realize its possibilities, and is welcoming American aid in the development of its enormous resources of cheap, efficient labor, and great natural resources.

The engineer who goes abroad should be able to associate with the well-educated, eminent, foreign engineers; with bankers, cabinet ministers, presidents, and kings with just the same right degree of cordiality with which he would treat a contractor, a drill runner, or a mule driver. A practical working knowledge of a foreign language, sound enough to get at the real heart of the people, is essential in this kind of work.

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SHOP LIGHTING.

In an address delivered before the members of the Western Pennsylvania Division of the National Safety Council, Pittsburg, Pa., March, 1918, by C. W. Price, the importance of good lighting in industrial establishments was discussed, and the disadvantages of poor lighting were clearly shown by some figures mentioned by Mr. Price.

A large insurance company analyzed 91,000 accident reports, for the purpose of discovering the causes of these mishaps. It was found that 10% was directly traceable to inadequate lighting and in 13.8% the same cause was a contributory factor. The British Government in a report of the investigation of causes of accidents determined a close parallel to the findings of the insurance company above quoted. The British investigators found that by comparing the four winter months with the four summer months, there were 39.5% more men injured by stumbling and falling in winter than in summer.

Mr. John Calder, a pioneer in safety work, made an investigation of accident statistics covering 80,000 industrial plants. His analysis covered 700 accidental deaths, and of these 45% more occurred during the four winter months than during the four summer months.

Mr. C. L. Eschleman, in a paper published in the proceedings of the American Institute of Electrical Engineers several years ago, reported the result of an investigation of a large number of plants in which efficient lighting had been installed. He found that in such plants as steel mills, where the work is of a coarse nature, efficient lighting increased the total output 2%; in plants, such as textile mills and shoe factories, the output was increased 10%.

In an investigation of the causes of eye fatigue, made by the Industrial Commission of Wisconsin, it was found that in a large percentage of industries, such as shoe, clothing and textile factories, the lack of proper lighting (both natural and artificial) resulted in eye fatigue and loss of efficiency. At one knitting mill, where a girl was doing close work under improper lighting conditions, her efficiency dropped 50% every day during the hours from 2:30 to 5:30 P. M.

The above mentioned incidents indicate how important a factor lighting is in the operation of the industrial plant. It has been well said, "Light is a tool, which increases the efficiency of every tool in the plant." Glare or too much light is as harmful as not enough lighting, and in no case should the eyes of the workers be exposed to direct rays, either of sun or electric light.

Windows and reflectors should always be kept clean; that is, cleaning them at least once a week, for where dust and dirt are allowed to collect, efficiency of the light is decreased as much as 25%.

Good lighting, in addition to its other marked advantages, is a strong incentive towards keeping working places clean, for it clearly exposes any place where dirt or other material has been allowed to collect. White walls and clean windows glazed with Factrolite Glass will eliminate the sun glare and increase the illumination 25 to 50 feet from the window from 38% to 72% as compared with plain glass.

Lighting is of primary importance to every employer and fully warrants a careful investigation of the subject, for there is no substitute for good lighting, and if it is not supplied the efficiency of the entire working force must suffer a serious reduction.

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SIX BILLION KWH FOR NEW ENGLAND INDUSTRIES

Although there seems at present to be a distinct lull in engineering activities in the East, there are indications that the near future will see greatly improved conditions. Among the projects which are considered for action as soon as conditions are more settled is that of utilizing more fully the hydro-electric power of the St. Lawrence. Mr. Henry I. Harriman, former president of the Boston Chamber of Commerce and head of the New England Power Company, has done a great deal of investigation along this line and has issued a pamphlet entitled "The St. Lawrence Project and its Meaning to New England."

In this booklet, Mr. Harriman says that there are 26,000,000,000 kilowatt-hours available between Lake Ontario and the mouth of the river. Of these, one-half should go to the United States; and of that half, he says, 6,500,000,000 kilowatt-hours should be allowed to New England. This is equivalent to six billion kilowatt-hours delivered to the sub-stations of New England. This power, according to the latest figures, should be delivered in wholesale quantities in the New England States and New York at less than one cent per kilowatt-hour.

After Russia and Mexico, the rest of us have settled down to the conclusion that the revolutions the earth makes on its axis are enough.—*Transcript.*

PROFESSOR PEABODY

(*Continued from Page 111*)

In 1920, after forty-three years of active teaching, thirty-seven of which were devoted to Technology, Professor Peabody was retired with the title of Professor Emeritus of Naval Architecture at the Massachusetts Institute of Technology.

Professor Peabody ranks with the great upbuilders of the Massachusetts Institute of Technology. He combines the talents of the educator and the administrator to an exceptional degree. Always dignified, always composed, he is a man among men. He will ever maintain the deepest respect and affection of all who know him.

Inquiries continue to suggest themselves as to what some of the Edison questionnaires have to do with the electricity business.—*Washington Star.*

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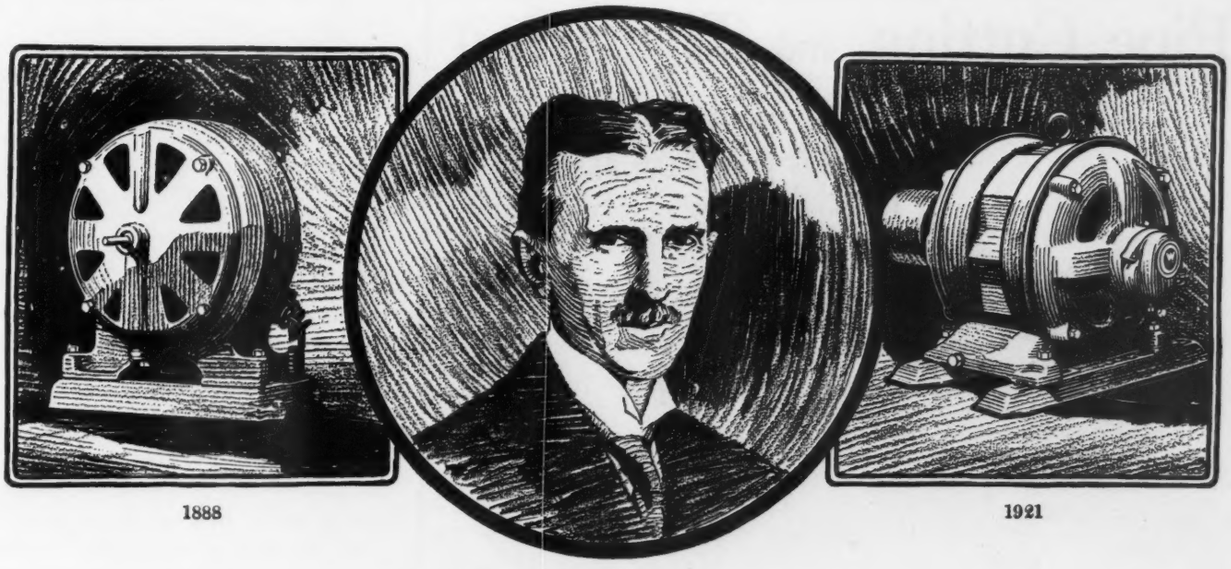

1888 1921

Nikola Tesla

THE NAME of Nikola Tesla will always be associated with the invention and earlier developments of the induction motor. In fact, at one time this type of apparatus was known almost exclusively as the "Tesla" motor.

Tesla devised this motor back near the beginnings of the electrical business, when practically everything was built by "cut and try" methods, and none of the accurate analytical processes of later days had been developed. It may be said broadly that Tesla knew two fundamental facts—first, that if a magnet were moved across a sheet of conducting metal, it would tend to drag this metal along; and,—second, that the *effects* of such a moving magnet could be produced by suitably disposed polyphase currents acting on a *stationary* magnetic structure.

Perhaps others, at that time, also knew these two facts, but if so, apparently they knew them only as two isolated facts. Tesla considered them *in combination* and the result was the Tesla motor, or what is now known broadly as the "induction motor." These two facts, in combination, represent a fundamental conception, and all of the many millions of horsepower of induction motors in use today throughout the world, are based upon these two fundamentals.

Naturally, Westinghouse, having fought single handed to advance the alternating current system, was supremely interested in the new type of motor. What if the new motor did require polyphase circuits, while all existing circuits were single phase? What if it did require lower frequency than any existing commercial circuits? These were merely details of the future universal alternating system. The important thing was to obtain an ideally simple type of alternating current motor, which Tesla's invention offered. Tesla furnished the fundamental idea.

He and his associates, working for Mr. Westinghouse, proved that thoroughly operative induction motors could be built, provided suitable frequencies and phases were available. What matter if they did not produce an operative commercial system at the time? What matter if it needed the powerful analytical engineers of later date to bring the system to a truly practicable stage—men with intimate constructive knowledge of magnetic circuits—men on intimate terms with reactive coefficients and other magnetic attributes totally unknown to Tesla and his coworkers? In time the motor was made commercial, and it has been a tremendous factor in revolutionizing the electrical industry.

Probably no one electrical device has had more high-power analytical and mathematical ability expended upon it than the induction motor. The practical result has been one of the simplest and most effective types of power machinery in use today. Thus Tesla's fundamental ideas and Westinghouse's foresight have led to an enormous advance in the world's development.

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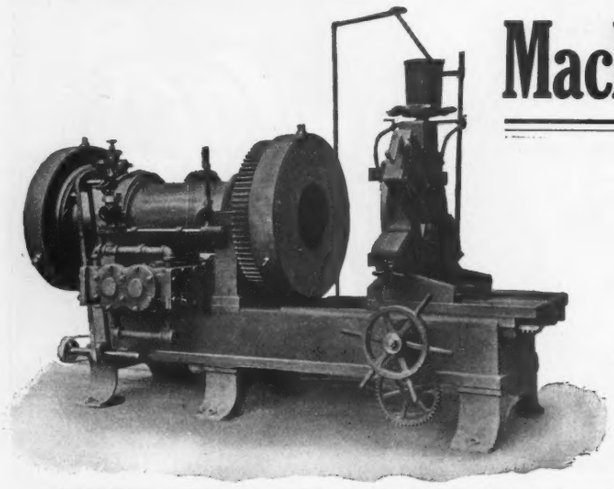

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On every side of the Engineer in his professional career there are mechanisms a millionfold more complex than the most ingenious mechanical creation of man's mind. If he is to succeed, he must learn to control not only the mechanical factor but also the human factor. This sort of control is apparently instinctive on the part of certain leaders; in most men it must be cultivated.

The question of cultivation is solved without unusual effort. First, the man who desires to control others must learn self-control. To control himself, he must understand himself. He should catalogue his instincts, emotions, and physical traits. To do this intelligently, he should apply psychology, the youngest of sciences. Having gotten into right relation with himself, the man who aspires to be a human engineer should quietly observe and study his associates. In conversation, he should endeavor to penetrate to the real self of those with whom he is thrown into contact. He must appreciate hidden causes, dominating motives governing their behavior. He should develop the ability to put himself in another man's shoes and borrow his mentality. By so doing, his understanding of the other fellow becomes definite. He knows where the levers are and how gauge readings should be interpreted. He is thus enabled to control. In controlling, he is dominating the situation. If the engineer can prove without doubt that he knows not only how to design a skyscraper, but that he can don the mental garb of a laborer, seeing the day's task through his eyes, he can make his building a reality. Prestige is attained in this way. Success follows. Why not have more of the sort of training essential to human engineering incorporated into our curriculum?

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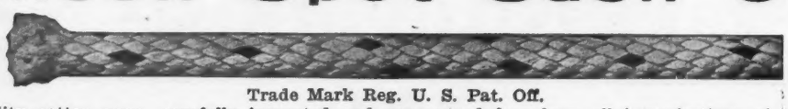

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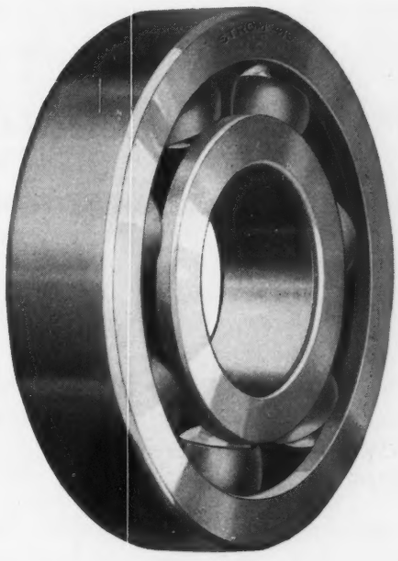

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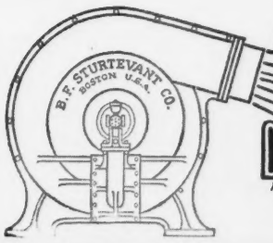

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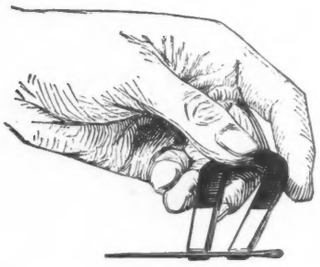

Why Is Iron Magnetic?

A horse-shoe magnet attracts a steel needle. But why? We don't know exactly. We do know that electricity and magnetism are related.

In dynamos and motors we apply electro-magnetic effects. All our power-stations, lighting systems, electric traction and motor drives, even the ignition systems of our automobiles, depend upon these magnetic effects which we use and do not understand.

Perhaps if we understood them we could utilize them much more efficiently. Perhaps we could discover combinations of metals more magnetic than iron.

The Research Laboratories of the General Electric Company investigate magnetism by trying to find out more about electrons and their arrangement in atoms.

X-rays have shown that each iron atom consists of electrons grouped around a central nucleus—like planets around an infinitesimal sun. X-rays enable us to some extent to see into the atom and may at last reveal to us what makes for magnetism.

This is research in pure science, and nothing else. Only thus can real progress be made.

Studies of this kind are constantly resulting in minor improvements. But some day a discovery may be made which will enable a metallurgist to work out the formula for a magnetic alloy which has not yet been cast, but which will surely have the properties required. Such a result would be an achievement with tremendous possibilities. It would improve all electric generators, motors, and magnetic devices.

In the meantime the continual improvement in electrical machinery proceeds, in lesser steps. These summed up, constitute the phenomenal progress experienced in the electrical art during the past twenty-five years.

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